The Philippine Journal of Agriculture

[Formerly THE PHILIPPINE AGRICULTURAL REVIEW]

VOL. III THIRD QUARTER, 1932 NO. 3

THE SLUG CATERPILLAR ON ABACÁ (*THOSEA SINENSIS* WLK.), ITS LIFE HISTORY AND HABITS AS OBSERVED IN DAVAO, AND SUGGESTIONS FOR CONTROL

By PEDRO SISON

Assistant Agronomist, Bureau of Plant Industry

SIX PLATES

Slug caterpillars were rather numerous during 1929–1930, more than 2,500 hectares of abaca having been badly attacked. The infested areas comprised the barrios of Talomo, Libby, Bago, Mulig and Daliao of the municipality of Davao and in the barrios of Ola and Tugbuk of the municipal district of Guianga. Because of these serious infestations the writer was sent to Davao early in 1931 by the Director of Plant Industry to make observations on these pests and to help in the control work.

There are at least two species of slug caterpillars present in Davao Province feeding upon the leaves of abacá. One is naked, ash-colored and is considered of minor importance so far. The other, the one discussed in this paper, is a thorned species of poisonous character.

There are different beliefs among the farmers of Davao as to the occurrence of the pest in the fields. Farmers of Libby, Talomo, and Guianga believe that the caterpillars become abundant only during the hot months and disappear when the rainy days occur, because they are washed off. The assistant manager of the Christensen Company, at Padada, Santa Cruz, believes otherwise. According to him the pest becomes noticeably abund-

ant during the rainy days as observed in the locality and disappears during the hot months.

These beliefs contradict each other but the farmers of Talomo, Libby, and Daliao may be right as to one reason, for during the hot days, especially in the case of a short drought, there is a scarcity of flowers which kills the natural enemies, the hymenopterous parasites. The writer is inclined to believe that rain has not much effect on the larvæ, as they are well protected by the leaves, and that their disappearance from the fields is due to the fact that they have gone down under the earth to pupate.

ECONOMIC IMPORTANCE

Formerly the pest was known to feed only on coconuts and was then considered of minor importance because it was held in check by the natural enemies, such as the parasites, predators and possibly other factors. But recently it became numerous in several sections of the Islands, riddling the leaves of both coconuts and abacá over wide areas. In serious cases, the abacá plants visited by the pest are deprived of their leaves, only the petioles being left and in the case of the coconuts, the fronds are skeletonized down to the midribs of the pinnæ. (Plates III and IV.)

CLASSIFICATIONS AND LOCAL NAMES

The pest belongs to the Order Lepidoptera, Family Limacodidae (Euclidæ) and is known in science as *Thosea sinensis* Wlk. In the Bureau of Science collection, Manila, the species was identified by W. Schultze, former entomologist of the said Bureau, from specimens collected in 1904. His identification was based from the description of this species in Hampson's Fauna of British India. The same identification was made of the specimens taken to the States by G. Merino, chief, Plant Sanitation Division, Bureau of Plant Industry, Manila, according to the report received from him (1931). Commonly it is termed as the slug caterpillar because the larvæ resemble slugs, especially as to locomotion. Comstock(1) says: * * * the resemblance to slugs is greatly increased by the fact that the lower surface of the body is closely applied to the object upon which the larvæ is creeping, the pro-legs being replaced by mere swellings of the abdominal segments."

In the Tagalog provinces, it is popularly known as "pagui-pagui" because it resembles the sting ray fish, (*Dasyatis sabina*) in shape and roughness of the skin. However, in some sections it is called "apuy-apuyan" (fire) for the reason that the larva

produces a hot irritant feeling when the thorned hairs touch the skin. In the Province of Davao there is no specific name applied and the Filipino farmers, especially the Visayans, call it "mamang," a general term applied to all insects, whether they are destructive or not.

DISTRIBUTION

The pest is present in the Island of Luzon, as specimens have been collected in Manila and in its vicinity. It was also observed in the coconut-growing provinces and has done damage in Negros, Samar, the Camotes Islands, Cebu, Cagayan, and Davao. It is therefore widely distributed in the Philippines and is probably present wherever there are coconuts and abaca.

Speaking particularly of the places around the Gulf of Davao, it is present in scattered localities infesting both abacá and coconuts. It has been observed in the municipalities of Davao, Guianga, Santa Cruz, Mati, Malita, and Kingking. (See diagram.)

As to when it appeared in the Province of Davao there are no data available, but fieldmen of the old Bureau of Agriculture observed the pest during the year 1920 on the abacá plants near the municipality of Davao, but it did not spread. According to the information received from the Talomo Plantation Company, it was present in the plantation during the year 1922 but to no noticeable extent. Yearly infestations followed occurring at different places and it became serious only during the years 1929 and 1930, infesting about 75 per cent of the 360 hectares planted to abaca. During the same years the pest also did damage to the neighboring plantations in the barrios of Bago, Daliao, Talomo, Mulig, Ola, and Tugbuk. All in all during these years it infested an area of more than 2,500 hectares.

Another place where it has done serious damage though not on abacá but on coconuts is in the plantations of the Christensen Company, and the Mindanao Estate, at Padada, Santa Cruz. It occurred also during the same years and has covered an area of more than 60 hectares.

In 1926, Mr. Villalon, a plant quarantine inspector of the Bureau of Plant Industry at the port of Davao, observed the pest in barrio Taragona, Mati. It was present also on coconut trees in an alarming number.

The species was reported to be present in Hongkong, Formosa, Cachar, Penu, and Java, according to Hampson(3) and in other countries near the Philippines.

HOST PLANTS

The larvæ of the pest feed on many different host plants. In Davao, it was observed actually feeding on the leaves of the following plants: (1) Abacá, (*Musa textilis*) all varieties; (2) banana, (*Musa sapientum*); (3) coconut, (*Cocos nucifera*); (4) wild palms, one of them is "pugahan," (*Cariota urens*); (5) mango, (*Mangifera indica*); (6) corn, (*Zea mays*); (7) sugar cane, (*Saccharum officinarum*); (8) "anonang"; and (9) wild grasses.

Of these hosts, the pest prefers the coconut and abacá and feeds on all varieties of the latter planted in Davao, namely Tangongon, Libuton, Lawanon, Bungolanon, and Maguindanao. It is of interest to note, however, that the variety Maguindanao is not as susceptible as the other varieties, partly because of its resemblance to the banana plant.

Nevertheless this variety cannot be recommended for extensive planting because it is not as productive as some others. It is for this reason that the variety is now being discarded by planters in Davao.

NATURE AND EXTENT OF DAMAGE

The newly hatched larvæ feed on the lower surfaces of the leaves, leaving the upper epidermis or contrariwise at times. Their presence on the leaves is noticed because of the whitish irregular-shaped spots they leave.

When they are in the third instar, they begin to consume the whole tissue, making irregular cuts, and continue feeding until they are in the fullgrown stage. They produce numerous holes and cuts both through the blades and along the edges of the leaves and in extreme cases the whole blade is eaten up, only small portions along the petioles being left. (Plate III.)

Because of the long larval stage of the pest, one caterpillar can consume a big leaf area before it pupates and it was observed at the Talomo Plantation Company that three larvæ, from hatching to the full-grown stage, can totally consume the blade of a leaf about one meter long.

In Catalunan Pequeño, a sitio of barrio Talomo, the pest has completely destroyed the leaves of abacá plants over about six hectares. Both the old and young leaves were eaten. (See picture.) The same degree of damage was observed in the Talomo Plantation Company, and the neighborhood covering a very much bigger area.

As a result of complete defoliation, the soil beneath is exposed to the heat of the sun, which soon dries it out. The infested plants, therefore, take much longer to recover and become somewhat stunted for lack of moisture in the soil.

On coconuts, the same degree of damage is done but small portions along the midribs of the pinnæ are left, which results in injury like that done by locusts. At the Christensen plantation in Padada, Santa Cruz, the pest skeletonized from two to six fronds of young coconuts covering an area of more than 60 hectares. They took much longer to recover than the abacá because of their slow growth. (See picture.)

However, it was observed that even if the plants were seriously damaged, they did not succumb to the attack. The abacá plants become normal again after about four months (see picture) and this is one of the reasons why many farmers do not pay much attention to the pest.

METHODS OF STUDY

Egg stage.—Many cocoons were collected from the field and placed in battery jars. When the adults emerged, couples were placed in separate cages with living plants and fed with diluted sugar solution. The adults successfully laid their eggs and the length of the egg stage was taken. The egg-laying capacity was observed as well as the longevity of the adult stage.

Larval stage.—The newly hatched larvæ were placed in separate containers and fed daily with fresh leaves and labeled accordingly. This method failed, for when the larvæ were in the third stage they became abnormal, failed to feed and consequently died later. Larvæ were also placed in plants inside the cages, but the life cycle was not also followed successfully because they were attacked by the ants. Observations were, therefore, made later in the field. Eggs were marked, numbered and tagged or numbered to locate them easily and to tell one from the other.

The resulting larvæ were marked on the back with red ink so they could be traced in case they transferred to other leaves. Only the marked larvæ were left on any plant, and new ones that appear were killed immediately to prevent confusion. When they were about to pupate they were placed in separate battery jars and taken into the laboratory, where they were allowed to spin cocoons and pupate.

The development of the larvæ was also observed starting from the different instars but in this case the writer was not able to

follow the different instars completely for the reason that the larvæ after molting ate the cast skins. It is therefore hard to determine whether the larvæ molted during the time of observation. Because of this and besides because most of the time was devoted to other phases of the work, the different larval moltings were not completely recorded.

One hundred nine larvæ were used for the determination of the larval stage and only 14 were successfully followed because under field conditions they were severely attacked by the natural enemies.

Cocoon stage.—Full-grown larvæ were collected and were placed in battery jars in the laboratory, and also fed daily with fresh leaves. When they began to pupate, each cocoon was placed in a separate container with moist soil to avoid drying. Out of the 61 cocoons under observation only 27 successfully developed to adults.

Tests with insecticides were made direct in the field.

Through the courtesy of Mr. David M. Burchfield, proprietor of the Talomo Plantation Company at Libby, space was given in his store where the laboratory work was carried on in connection with the study of the pest. Likewise he gave his field for experimental purposes and furnished labor and some materials as well as other things needed.

LIFE HISTORY AND HABITS

The adult moths do not fly far from the places where they emerge, as reinfestations were observed in the same places or on new areas adjacent to the last infestations. These were observed at Talomo, Libby, and Tugbuk. The adults hide in between the hanging dried leaves of abacá and at times they are seen on the fresh leaves during the day. They were observed to be thickest on the former where they are well protected from their natural enemies because they are of the same color. They are nocturnal and, therefore, do their egg-laying, feeding and mating at night. When disturbed, they readily fly short distances without any definite direction. While in flight, they produce a sound similar to that made by the sphinx moth.

When the moths are at rest, they cling to the edges of objects with her wings pressed downwards. The abdomen is exposed and the anal end is slightly raised. The antennæ are slanted backwards resting on the back of the wings.

Matings take place during the night and at times during the day. The male and the female are in opposite positions attached to each other at the anal segments. Sometimes both are found clinging to the same object but in most cases the female clings and the male hangs freely down.

The eggs are laid a day after copulation in groups of from two to seven under field conditions and under control as high as 27 eggs were counted in a group. They are deposited along the edges of the leaf blades and on the middle of the lamina, generally on the lower surfaces of the leaves of the suckers and sometimes on the older ones. The eggs usually overlap a little at the ends and are laid crosswise or parallel to the veins, but, in some instances, they are found in other positions. The eggs hatch in from five to eight days with an average of 6.16.

TABLE I.—*Incubation period—First set*

Ind. No.	Date laid	Date hatched	Number of days	Remarks
30	III– 4–'31	III–11–'31	7	Observed under field conditions..
31	III– 3–'31	III– 8–'31	5	
37	III– 5–'31	III–11–'31	6	
38	III– 5–'31	III–12–'31	7	
39	III– 5–'31	III–12–'31	7	
76	III–19–'31	III–26–'31	7	
77	III–19–'31	III–26–'31	7	
80	III–19–'31	III–24–'31	5	
89	III–23–'31	III–28–'31	5	
90	III–23–'31	III–28–'31	5	
91	III–23–'31	III–28–'31	5	
92	III–23–'31	III–28–'31	5	

TABLE Ia.—*Incubation period—Second set (109 eggs)*

Date laid	Date hatched	Number hatched	Number of days	Remarks
IV–4–'31	IV– 9–'31	26	5	Under controlled conditions.
IV–4–'31	IV–10–'31	43	6	
IV–4–'31	IV–11–'31	32	7	
IV–4–'31	IV–12–'31	8	8	

Maximum, 8 days; minimum, 5 days; average, 6.16 days.

The young larvæ do not feed at once but rest during the first day and begin feeding the following day. They stay on the lower surfaces of the leaves where the eggs are laid and many are observed on a single leaf when the larvæ are still small. When they reach the size of about 20 millimeters, or the third instar, they scatter to the upper leaves. They do not stay permanently in one place but move from leaf to leaf during the

course of the feeding period. The larval stage lasts from 47 to 61 days, with an average of 55.67.

TABLE II.—*Duration of the larval stage*

Ind. No.	Date hatched	Date inclosed in the cocoon	Number of days	Remarks
28	III– 4–'31	IV–29–'31	56	
30	III– 4–'31	IV–30–'31	57	
31a	III– 6–'31	IV–26–'31	51	
34	III– 6–'31	V– 2–'31	57	
35	III– 6–'31	V– 4–'31	59	
44	III– 7–'31	V– 5–'31	59	
52	III– 7–'31	V– 3–'31	57	
54	III– 8–'31	V– 8–'31	61	
62	III– 8–'31	V– 5–'31	58	
63	III–10–'31	V– 5–'31	56	
74	III–10–'31	V– 4–'31	55	
78	III–19–'31	V–15–'31	57	
89	III–28–'31	V–14–'31	47	
90	III–28–'31	V–17–'31	50	

Maximum, 61 days; minimum, 47 days; average, 55.57 days.
NOTE.—Individuals observed are different from those in Table I.

The larva molts six times, beginning immediately prior to pupation. When they are about to molt, they stay in the middle of the leaf blade without feeding and shed their skin after four to five days.

The skin at the head breaks off and the larva slowly comes out. It turns back facing the cast skin and rests for a time until the new skin and the spinous tubercles (appendages) harden. The cast skin is then eaten up completely after which the larva begins to feed again on the leaves. There are, however, cases when the larval cast skins are not eaten but left attached to the surface of the leaves.

The larvæ usually feed during the night and cool parts of the day but those present in the interior of the plantations, especially when they are on the suckers, feed throughout the day resting only at intervals. When they have reached the full-grown stage, they crawl down to the bases of the abacá stems and begin to weave their cocoons wherein they pupate. They weave the cocoons on the surface of the soil under the dried leaves and other vegetable matter. They also locate them on the sides of the root stocks. These places are instinctively selected by the pest to prevent as far as possible the drying of the pupae up to the emergence of the adults. The cocoons are sometimes half buried in the soil and for this reason they are hardly recognizable as they resemble the latter in color and appear like small clogs of soil.

The larvæ upon weaving the cocoons coil themselves backwards in a circular position pressing one or two sides against

the object and move slowly during the process. It takes from six to eight hours before the weaving of the cocoon is finished. The larvæ shortly become yellowish and then pupate. The adults emerge after a period of from 26 to 33 days with an average of 28.59 days. They leave the cocoons through an exit hole on one end, especially constructed, whereby the lid is temporarily stuck to the main portion of the cocoon.

TABLE III.—*Duration of the cocoon stage*

Ind. No.	Date inclosed in the cocoon	Date emerged	Number of days	Remarks
1	II–15–'31	III–15–'31	28	
6	II–15–'31	III–13–'31	26	
7	II–16–'31	III–21–'31	28	
8	II–18–'31	III–16–'31	26	
12	II–18–'31	III–18–'31	28	
13	II–18–'31	III–16–'31	26	
15	II–19–'31	III–20–'31	29	
22	II–19–'31	III–20–'31	29	
23	II–20–'31	III–22–'31	30	
24	II–21–'31	III–21–'31	28	
25	II–21–'31	III–21–'31	28	
26	II–21–'31	III–21–'31	28	
27	II–22–'31	III–21–'31	27	
32	II–23–'31	III–23–'31	28	
37	II–23–'31	III–23–'31	28	
41	II–26–'31	III–31–'31	33	
45	II–27–'31	III–27–'31	28	
46	II–27–'31	III–27–'31	28	
52	III– 1–'31	III–29–'31	28	
53	III– 1–'31	III–29–'31	28	
54	III– 1–'31	III–31–'31	30	
56	III– 1–'31	III–31–'31	30	
57	III– 4–'31	IV– 1–'31	28	
58	III– 4–'31	IV– 1–'31	28	
59	III– 4–'31	IV– 4–'31	31	
60	III– 4–'31	IV– 4–'31	31	
61	III– 4–'31	IV– 5–'31	32	

NOTE.—Individuals reared are different from those in Table II.

	Days
Maximum	33
Minimum	26
Average	28.59

In these tables, the life cycle of the pest from the egg to the adult stage can be seen to vary from 78 to 102 days with an average of about three months. In one year, therefore, about four generations of the pest are possible.

TABLE IV.—*Summary of the life cycle from egg to adult*

Stages	Number of days			Remarks
	Minimum	Maximum	Average	
Egg	5	8	6.16	
Larval	47	61	55.57	
Cocoon	26	33	28.59	
Total	78	102	90.32	

LONGEVITY OF THE ADULT STAGE

Under laboratory conditions, the adults on the average live for a period of about four days. The range varies from two to fourteen days. In determining this, 50 adults were used; 30 were placed inside the cage, a meter cube, and 20 were placed inside the cylindrical cages one meter high and 0.5 of a meter in diameter. Inside the cages were living abacá and coconut plants and the adults were fed with diluted sugar solution. The result is shown in the following table.

TABLE V.—*Longevity of the adult stage—50 adults*

Date of observation	Number died	Number of days (duration)	Remarks
IV– 6–'31	.....	.....	Emerged.
IV– 7–'31	.....	.....	
IV– 8–'31	5	2	
IV– 9–'31	16	3	
IV–10–'31	13	4	
IV–11–'31	4	5	
IV–12–'31	3	6	
IV–13–'31	2	7	
IV–14–'31	.....	.....	
IV–15–'31	2	9	
IV–16–'31	1	10	
IV–17–'31	2	11	
IV–18–'31	.....	.....	
IV–19–'31	1	13	
IV–20–'31	1	14	

	Days
Maximum	14
Minimum	2
Average	4.78

PROPORTION OF MALES TO FEMALES

Counts were made of the adults that emerged from the cocoons collected from the field and figures showed that the proportion was about fifty-fifty. There were slightly more males than females.

TABLE VI.—*Proportion of males to females*

Date of observation	Number emerged		Remarks
	Males	Females	
III–31–'31	17	23	Adults were destroyed.
IV– 1–'31	14	13	
IV– 2–'31	15	1	
IV– 3–'31	7	7	
IV– 4–'31	13	11	
Total	66	55	

NUMBER OF EGGS LAID BY ONE FEMALE

The adults placed inside the cages were able to lay from 112 to 218 eggs but died before all of them could be laid. When the dead females were dissected, there were still eggs in the ovarian tubes. Adding these to the number of eggs already laid, each female, therefore, is capable of laying from 144 to 452 eggs. On April 8, 1931, four females were dissected after they had mated and as high as 508 eggs were counted in one of them. With the aid of a hand lens the eggs were easily traced and counted because they were placed in series inside the ovarian tubs resembling a string of yellow beads.

Dissection of spent females caught in the field showed the ovarian tubes empty, which was an indication that all the eggs in most cases are laid before the females die. From these data it seems safe to say that the females can lay from 144 to 508 eggs with an average of 315 eggs. It is therefore clear that a few adults in a locality can start a good brood any time and can increase to large numbers if they are not greatly hindered by the work of man and their natural enemies, as well as other factors.

TABLE VII.—*Number of eggs laid by one female*

Date	Number of eggs laid						Remarks
	F–1	F–2	F–3	F–4	F–5	F–6	
IV– 3–'31						49	
IV– 4–'31	111	83	61	129	62	133	
IV– 5–'31					132		
IV– 6–'31	[a] 32	111	120	14			F–1 died.
IV– 7–'31			33	6	18		
IV– 8–'31							F–2 died.
IV– 9–'31		[a] 76				41	
IV–10–'31							F–3, 4, 5, and 6 died.
IV–11–'31			[a] 9	[a] 98	[a] 87	[a] 229	

[a] Indicates the number of eggs counted when the dead female was dissected. F–1, 2, 3, and 4 emerged IV–1–'31; F–6 emerged III–31–'31; F–5 emerged IV–2–'31.

PER CENT OF EGGS THAT HATCH

As observed at the Talomo Plantation Company, under field conditions, the per cent of eggs that hatch is 95.45. There were no parasites observed and the dead ones, it is suspected, are unfertilized. Under laboratory conditions the per cent of hatch is 100. The following table is the result of the observations made in the field.

Number of eggs counted from dissected females

Female No.	Number counted
1	508
2	273
3	418
4	316

	Eggs
Maximum	508
Minimum	144
Average	315

TABLE VIII.—*Percentage of eggs that hatch in the field*

Leaf No.	Number of eggs found	Number hatched	Per cent	Remarks
1	3	3	.....	None parasitized.
2	2	1	.....	
3	3	3	.....	
4	1	1	.....	
5	3	3	.....	
6	2	2	.....	
7	4	4	.....	
8	9	9	.....	
9	6	6	.....	
10	4	3	.....	
11	5	5	.....	
12	3	3	.....	
13	2	1	.....	
14	6	6	.....	
15	4	4	.....	
16	4	4	.....	
17	1	1	.....	
18	1	1	.....	
19	2	2	.....	
20	1	1	.....	
Total	66	63	95.45	

NOTE.—Examination was done at the time when fresh eggs were no longer present.

DESCRIPTIONS

Egg.—The egg is oval, light yellow and translucent. It measures about 3.5 millimeters in length and about 2 millimeters in width. It is set flat on the surface of the leaf, is shiny and at times is not distinguished by an unexperienced observer. The covering is slightly rough and the larva forming is visible inside, usually at the center. In the advanced stage, the larva is seen in a curved position occupying one side of the egg and it comes out through a slit on the upper surface. When the egg is empty it is white, translucent, and stays attached to the leaf for some time. (Fig. 3, Plate I.)

Larvæ.—The newly hatched larva is light yellow with brown spots over the body and is from 2 to 2.5 millimeters long and from 1 to 1.5 millimeters wide including the thorny appendages.

At the lateral sides there are eleven pairs of these spinous tubercles of irregular lengths. The thorns or spines are few. Between the median line and the lateral spinous tubercles are nine pairs of short ones that are visible only when looked at with the aid of a powerful lens. (Fig. 5, Plate I.)

The full-grown larva is light green to yellowish green on the dorsal surface and from 34 to 38 millimeters long and from 22 to 24 millimeters wide including the thorny appendages. It is convex dorsally but flat ventrally thus resembling the true slugs. The skin is rough and somewhat corrugated. It has, like the newly hatched larva, eleven pairs of lateral spinous tubercles, the first two pairs from the posterior and much shorter than the rest. These have spines with light violet ends and black bases. The rest of the tubercles have spines with light yellow points mixed with those having long white hairlike ends. The color of the points shades down a little from the posterior to the anal segment. In the middle of the back is a light rose band running lengthwise with semi-undulated sides having eight pairs of distinct purplish spots. Opposite the nine lateral spinous tubercles near this band are nine pairs of grouped spines. They are very much shorter than the lateral ones and at times are not visible to the naked eye. The spines are of a poisonous character and irritate the skin. (Fig. 6, Plate I.)

At about the middle of the sides, starting from in between the lateral spinous tubercles, are depressions reaching the series of short spines, eight of which have a little violet spot at the upper end.

The head is yellowish blue with brown mandibles. It is hidden below the posterior end and is drawn back when the larva is disturbed. The ventral side of the larva is soft with transparent skin. It is sticky and holds fast to the object on which it rests. This portion is used for locomotion instead of the legs, and is moved with a wave like motion from the anal to the posterior end and the reverse when it moves backwards. It has three pairs of legs but they are of not much use for their purpose. Below the lateral spinous tubercles are eight distinct pairs of light brown colored spiracles.

Pupa.—The pupa is from 13 to 16 millimeters long and from 8 to 9.5 millimeters at its greatest diameter. At first it is creamy white and later when the adult is about to emerge the color changes to dark ash. It is very much shorter than the larva and shed its spinous skeleton. At this stage the parts of its adult are visible. (Figs. 7 and 8, Plate I.)

Cocoon.—The cocoon is oval with round ends and measures from 14 to 16 millimeters in length and from 11 to 13 millimeters in diameter. It is made of silk thread woven by the larva and is in two layers. At one end of the cocoon, above the head of the pupa, a circular portion is made up only of one layer to form the exit for the adult to pass through. It is purposely done so that it breaks easily when the adult moth pushes it up upon emerging. At first, the color of the cocoon when newly woven is light yellow but later it changes to dark brown, resembling in this case the color of the soil and dried leaves. (Fig. 9, Plate I.)

ADULTS

Male.—The general color is light brown, and shiny and it has brown and black spots. It measures about 18 millimeters from the tip of the head to that of the abdomen. The wings when fully expanded measure about 41 millimeters. The head is small with two distinctly serrated antennae and dark brown eyes. The thorax is thickly covered with hairs or setæ. The abdomen is tapering and a series of protruding hairs or setae is present at the end of the anal segment. The first pair of wings is characterized by the presence of a dark brown line running from the coastal margin, one-fourth of the distance from the apex to about the middle of the inner margin. The color from the outer margin to this line is darker than towards the base. A dark brown spot is present in between the costal margin and this line near the point of intersection. The inner pair has a darker color than the outer, but it is lighter towards the costal margin with no markings. The lower surfaces of both pairs of wings are tinged with brown spots, more distinct on the second pair. Each of the fore legs has a distinct white spot at the distal end of the tibia more or less covering the joint between this and the metatarsus, and the second pair has a dark brown spot at the ends of the tibia and femur. (Fig. 2, Plate I.)

Female.—The female is usually larger than the male but of about the same color. It measures about 23 millimeters from the tip of the head to that of the abdomen and about 48 millimeters from tip to tip of the wings when spread. The first pair of wings has the same markings as the male, but the dark brown spot is not very distinct and there are cases when this spot is

absent. Same markings are also observed on the first two pairs of legs. The abdomen is stouter, barrel shaped and possesses also anal tufts, but in the case of the female there are two distinct layers, the inner is of a chocolate color. The antennae are very much slenderer than those of the male and the characteristic of the serrate type is not clearly visible to the naked eye. (Fig. 1, Plate I.)

NATURAL ENEMIES

There are at least two species of hymenopterous parasites (Braconidae) the larvae of which feed and stay inside the slug caterpillar. Specimens of these two species have been sent to a specialist for identification. The larger measures about 4.5 millimeters and the smaller about 2.5 millimeters. The former attacks the larvae about 12 to 15 millimeters long or the third larval instar. Only one parasite was observed in one caterpillar. The smaller parasite attacks the third instar to full grown and many are found on one larva. There are cases where more than 200 of these parasites emerge from one slug caterpillar.

The bigger species pupates inside the slug and is therefore not visible from the outside. The latter species upon pupating goes out of the larva also passing through the ventral side and spins white, cotton-like cocoons below the larva. As a result of the work of these parasites, the larvæ are to be seen in mummified form resting on the cotton-like masses of cocoons attached to the leaves. (Fig. 5, Plate II.) The small species is more active than the other as it was able to destroy from about 80 to 90 per cent of the leaves as has been observed at the Ohta Development. (Fig. 4, Plate II.)

The adults of the small species were seen flying among the flowers of the cover crop, *Calopogonium mucunoides*. This made the writer suspect that they feed on the flowers of this cover crop, forming one of its hosts, and for this reason an observation was made. Infested trees were examined in plantations where there are Calopogonium and in places where there are none. Ten trees were selected at random from the previously infested trees covering an area of about half a hectare. The mummified larvae still attached to the leaves were counted. This observation was made on coconut plantations adjoining the abacá which are also infested by the same species of slug. The following table shows the result of this observation.

TABLE IX.—*The presence of the cover crop Calopogonium mucunoides in relation to parasitism*

TALOMO PLANTATION COMPANY, LIBBY, DAVAO

Tree No.	Number of parasitized larvæ counted		Remarks
	With Calopogonium as cover crop	With Calopogonium	
1	7	0	Cogon and camote vines are present in the lot without the cover crop.
2	6	0	
3	3	0	
4	2	0	
5	1	0	
6	1	0	
7	2	0	
8	8	0	
9	0	0	
10	0	0	
Total	30	0	

OHTA DEVELOPMENT COMPANY, BAGO, DAVAO

1	8	0	Meadow grass is present in the lot without the cover crop. Coconuts not bearing.
2	14	0	
3	6	0	
4	3	0	
5	7	0	
6	5	0	
7	15	0	
8	10	0	
9	8	0	
10	3	0	
Total	79	0	

PLANTATIONS IN BARRIO MULIG, DALIAO, DAVAO

1	0	0	All are without the cover crop.
2	0	0	
3	0	0	
4	0	0	
5	0	2	
6	0	0	Trees from 1 to 10 are not bearing, and from 11 to 20 are bearing.
7	0	0	
8	0	0	
9	0	1	
10	0	0	
11	0	0	
12	0	0	
13	0	0	
14	0	0	
15	0	0	
16	0	0	
17	0	1	
18	0	0	
19	0	0	
20	0	0	

From these observations, it is clear that there is slight relation between the presence of the cover crop and the abundance on the dead parasitized larvæ. This indicates, therefore, that the adult parasites are attracted by the flowers of this particular cover crop and are forced to work right in the infested spot or in the neighborhood.

A species of tachnid fly attacks the larva and completely kills it when the latter is in its pre-pupal stage. The adult flies lay their eggs on the body of the slug caterpillar (Fig. 1, Plate II), and the larvæ after hatching enter and feed inside the host. Pupation takes place when the slug caterpillars are already inside their cocoons. The fly parasite is not so very active, as it was observed to destroy only as high as 20 per cent in two generations. The adults of this fly parasite were seen flying among the flowers of the weeds in between the plantations, especially when aphids were present.

Another insect which attacks the larvæ of the pest is a species of predatory pentatomid bug, *Canthecona Furcellata* Wolff. It kills the larva by sucking its body juices. Both the nymphs and adults prey upon the larvæ.

2. *Birds.*—The crows prey upon the larvæ by picking them up with their bills and squeezing out the soft content. The thorny skin or skeleton is not swallowed. As many as fifty of them are to be seen in a flock working everyday from morning till late in the afternoon. They never leave the field until only a few of the larvæ are left.

Hens with their chicks search for the cocoons by scratching the soil around the bases of the abacá hills. The cocoons are cracked and the pupae are eaten.

3. *Other factors.*—A species of spider also preys upon the small larvae of the pest but this is scarce.

Bagobo Limocon and other Bagobos report that they have seen monkeys feed on the larvae by taking also the soft parts. They remarked, however, that the monkeys do more harm than good because they break the abacá leaves as they jump from leaf to leaf.

It was observed also that the heat of the sun kills the pupae and larvae inside the cocoons as when the new cocoons were put in a dry place about 90 per cent of them did not develop. The death under field conditions cannot only be attributed to heat but also to the other factors as even if they were half buried in the soil and well shaded by the hanging dried leaves, many of them were dead and there were cases when the pupae were coated with a white mass of fungus. Whether the fungus was the primary cause of death or not is not known. The following table lists the observations made on the cocoons collected from different plantations.

TABLE X.—*Per cent of dead pupæ due to parasite and other factors—from specimens collected in the field*

Locality	Date examined	Number of cocoons examined	Number emerged	Per cent	Number parasitized	Per cent
1. Talomo Plantation Co., Libby, Davao	IV– 3–'31	297	149	49.96	60	20.20
2. Talomo Plantation Co., Libby, Davao	IV– 3–'31	117	66	56.42	8	8.83
3. Christencen Plantation, Padada, Santa Cruz	IV– 8–'31	77	44	57.15	1	1.29
4. Catalunan, Pequeño, Talomo, Davao	IV–16–'31	134	80	59.71	21	15.67
5. Mintal Plantation Co., Tugbuk, Guianga	IV–16–'31	100	60	60.00	8	8.00

Locality	Date examined	Number of cocoons examined	Number dead with and without fungus	Per cent	Total per cent dead	Remarks
1. Talomo Plantation Co., Libby, Davao	IV– 3–'31	297	86	29.84	50.04	.....
2. Talomo Plantation Co., Libby, Davao	IV– 3–'31	117	43	36.75	43.58	.....
3. Christencen Plantation, Padada, Santa Cruz	IV– 8–'31	77	32	41.56	42.85	.....
4. Catalunan, Pequeño, Talomo, Davao	IV–16–'31	134	33	24.62	40.29	.....
5. Mintal Plantation Co., Tugbuk Guianga	IV–16–'31	100	32	32.00	40.00	.....

	Per cent
Maximum	50.04
Minimum	40.00
Average	43.35

In this table, it can be seen that the percentage of pupæ inside the cocoons that were dead due to heat, fungus or what not is from 29 to 41. Adding to this, the work of the fly parasite, the percentage of pupæ destroyed varies from 40 to 50 or an average of 43.35 per cent.

TRIALS WITH INSECTICIDES

1. SOAP SOLUTION AS A CONTACT SPRAY

Larvae of different sizes were collected and placed on the leaves of abacá. Three sets were prepared and they were sprayed with the different concentrations of insect liquid soap (44 per cent). The proportions used were $\frac{3}{4}$ salmon canful of the liquid soap to about 20 liters of water (1:50); one salmon canful to the same amount of water (1:36) and $1\frac{1}{2}$ salmon canfuls to the same amount of water (1:26).

After spraying, the larvæ were placed in three separate battery jars with fresh unsprayed leaves of abacá. Sixty (60) unsprayed larvae were placed in a separate battery jar also fed with fresh leaves to serve as control. Four hills of abacá, one

in a set, were sprayed with the different concentrations used, to determine the effect on the leaves. The following table shows the results:

TABLE XI.—*Trials with soap solution (Legarda insect liquid soap, 44 per cent)*

Observation		Number of larvæ used	Amout of liquid soap for 5 gallons of water	Time succumbed	Number revived	Per cent killed	Remarks
Date	Time						
II-10-'31	3.04 p. m.	87	[a] ¾	3.05 p. m	.....	.....	Big ones revived but failed to feed while inside the battery jar.
II-10-'31	3.44 p. m.	.....	.....	.....	15	82.75	
II-11-'31	7.00 a. m.	.....	.....	.....	15	.....	
II-12-'31	7.00 a. m.	.....	.....	.....	20	.....	
II-13-'31	7.00 a. m.	.....	.....	.....	4	.....	
II-14-'31	7.00 a. m.	.....	.....	.....	0	.....	
II-10-'31	2.40 p. m.	70	[a] 1	2.41 p. m	.....	.....	Do.
II-10-'31	3.40 p. m.	.....	.....	.....	6	84.21	
II-11-'31	7.00 a. m.	.....	.....	.....	2	.....	
II-12-'31	7.00 a. m.	.....	.....	.....	4	.....	
II-13-'31	7.00 a. m.	.....	.....	.....	0	.....	
II-10-'31	3.40 p. m.	60	[a] 1.5	3.41 p. m	.....	.....	Do.
II-10-'31	5.00 p. m.	.....	.....	.....	0	100.00	
II-11-'31	7.00 a. m.	.....	.....	.....	2	.....	
II-12-'31	7.00 a. m.	.....	.....	.....	5	.....	
II-13-'31	7.00 a. m.	.....	.....	.....	0	.....	
II-10-'31	4.00 p. m.	60	[b]	.....	.....	None	Larvæ fed while inside the battery jar.
II-11-'31	7.00 a. m.	.....	.....	.....	.....	Died	
II-12-'31	7.00 a. m.	.....	.....	.....	.....	.....	
II-13-'31	7.00 a. m.	.....	.....	.....	.....	.....	
II-14-'31	7.00 a. m.	.....	.....	.....	.....	.....	
II-15-'31	7.00 a. m.	.....	.....	.....	.....	.....	

[a] Salmon can. [b] Control.

The solution had an immediate effect upon the larvæ, the more so in the case of the young ones. The last concentration, during the first day, gave the best results, 100 per cent of them dying. Only a few revived on the following days and they were very weak and died just on the third day. When the larvæ are wet by the spray, the head and lateral thorny appendages rise up, coil a little backwards and then drop to the ground. They are forced to drop to the ground because the soap solution makes the smooth surface of the abacá leaves very slippery.

In the case of the control set, none of the larvæ died within four days, after they were placed in the battery jar and unlike the sprayed ones, they fed on the abacá leaves.

On February 18, 1931, with the use of a bucket spray pump, fifty hills of abacá were sprayed with a solution made of 1.5 salmon canfuls of soap to about twenty liters of water (1:26). The larvæ were thoroughly wet and from 80 to 90 per cent of them dropped dead to the ground. On the next day a few revived but they were not able to climb back onto the plants for the reason that they could not move well on the surface of the

soil and besides, they were immediately attacked by red ants. The larvæ sprayed were in the third to full grown stages.

On February 22nd, 125 larvæ consisting of newly hatched ones and about the third larval stage were sprayed with a solution made of the 1 salmon canful of soap to about 20 liters of water (1:36). All of them immediately succumbed and none revived on the same day. On the next day, only five of those in the third larval instar revived but they died the following day.

On April 17, 100 newly hatched larvæ were collected without removing them from the leaves and sprayed with soap solution using the concentration of ½ salmon canful to about 20 liters of water (1:60). All of them succumbed immediately and none of them revived.

Effect of the soap spray on the plants.—None of the different concentrations of the soap solution tried had any burning effect on the leaves. The only part affected is the base of the leaf petiole where a portion of the solution collects during spraying. When the solution dries out, it becomes more concentrated and burns to a slight extent. The burning does not extend to the interior of the bud, as the scorched portion is carried up when the leaf grows.

2. CALCIUM ARSENATE AND SOAP

On February 16, ten infested hills of abacá were sprayed with the solution having the following formula:

Insect liquid soap	560 cubic centimeters.
Calcium arsenate	60 grams.
Water	19 liters.

This formula was intended both for a contact and a stomach poison. After spraying, the young larvæ succumbed but many of the full-grown ones revived and continued to feed. In this case, the leaves even without the larvæ were sprayed with the mixture.

On February 26, ten days later, one or two dead larvæ were seen on each leaf. However, they become scarce. The mixture gave results, but not to the desired extent as far as poisoning was concerned. The original infestations varied from 42 to 79 larvæ per hill and when they were counted on the 26th, the number varied from 18 to 32 per hill.

Effect on the plants.—On the third day after spraying, the bases of the leaf petioles were found to be worse scorched than

when soap was used alone and some of the leaves had begun to wilt. The leaf blades had burned patches, which were very conspicuous, and more of the riddled leaves. (Fig. 6, Plate II.) Because of these discouraging results, further trials were not made and no more of the solution was employed for the control of the pest.

LIGHT TRAPS

Two simple light traps were set at the Talomo Plantation Company consisting of lanterns (Dietz type) placed over basins with water and a little kerosene. They were set in the plantation where fresh eggs were seen daily, an indication of the presence of adults. The traps were set for four nights but no moths were caught. Instead, small hymenopterous insects and small moths were collected, but none of the parasites were seen.

Through the suggestion of the writer, light traps were also set in the Mintal Plantation Company at Tugbuk using the same method. Twenty lights were set in different places and for several nights, but the manager of the plantation reported that not even a single adult was attracted.

These trials prove that the adults of the slug caterpillar, *Thosea sinensis*, are not attracted to such dull lights as the lanterns used. They were, however, attracted to the electric lights at the residence of the assistant manager of the Talomo Plantation Company with a power of 100 candles. To attain good results, therefore, the light should be very bright with a power of 100 candles. Trials, however, should first be made before employing bright lights extensively for more parasites than moths may be attracted and thus the traps may do more harm than good.

CONTROL MEASURES

Because of the fact that the pest feeds on many kinds of hosts and is present on permanent crops, its control is rather difficult. However, it can be reduced to a harmless minimum if the following methods are persistently employed by the farmers.

1. *Collection of the larvæ.*—This can be done by hand picking in the case of low plants, and the leaves of tall plants loaded with the larvae should be cut off and burned or destroyed in whatever way depending on local conditions make advisable. To keep the hands from the poisonous effect of the larvæ, gloves may be worn or they can be picked up with home-made bamboo forceps. Care should be taken that the parasitized larvæ are not included in the destruction but picked out from the bunch

and put in the field in places where they will be well shaded so that the adult parasites will be set free.

Whenever they are noticed in the field, even if in small areas, they should be destroyed immediately to stop serious outbreaks of following broods, as one female can lay over 500 eggs.

2. *Collection of the cocoons.*—The cocoons can be easily gathered from around the bases of the abacá plants where the larvæ pupate. The cocoons should not be destroyed, but placed in boxes and then covered with wire netting 16 mesh to the inch. Holes about the size of a kernel of corn should be made through this wire netting so that the fly parasites that will emerge can escape but not the adult moths. The boxes should be placed in the plantations, well shaded and protected from the attacks of ants.

Community coöperation is essential to attain good results. In Davao, Mindanao, a municipal ordinance was passed to the effect that all able-bodied men between the ages of 16 and 60 must assist in the destruction of the pest working two days a week. It gave good results as the men were able to destroy a considerable number of the pest daily.

3. *Spraying with soap solution as contact poison.*—The larvæ of the pest are killed by soap solution prepared by mixing insect liquid soap with water at the proportion of one part to (20–60) parts water, depending upon the ages of the larvæ. The spray should be directed to the lower surfaces of the leaves where the larvæ stay and the leaves should be thoroughly wet with the solution. The weakest solution is used for the newly hatched larvæ and the concentration is increased as the larvæ become bigger. It is to be remembered that the soap is a contact spray and should be used only when there are caterpillars on the leaves.

Precautions, however, should be taken that only fields showing a very low percentage of parasitism are sprayed. Fields with a percentage of over 50 per cent can be left alone and collection by hand or by other means resorted to.

If liquid soap is not available, soft yellow Chinese soap may be used instead. Dissolve $\frac{1}{4}$ to $\frac{1}{2}$ kilo of the soap in about 5 gallons of water. For newly hatched larvæ a more diluted solution will do.

A bucket spray pump with 15 meters of rubberhose ($\frac{5}{8}$ inch diameter) will serve for spraying purposes. A power pump with about 100 meters rubber hose can also be used. A long hose is very necessary in the case of old plantations where the

rows are already destroyed, but in the case of new plantations, the power pump can be put on to a bull cart or sled. (Plate VI.)

4. *Transferring and encouraging the natural enemies.*—The parasites should be transferred from the places where they are found abundant to places where they are scarce. This is done by collecting the parasitized larvæ with the immature stages of the parasites without taking them off the leaves and then putting them on abacá stems in places where there are plenty of larvæ. They should be well shaded to prevent too fast drying as that stops the development of the parasites.

These parasites should be encouraged by planting food plants for the adults. In the case of the small Braconid parasite, the cover crop *Calopogonium mucunoides*, should be planted in the open spaces and in between the abacá plantations or along the edges.

When there are chickens, they should be let loose in the fields when the pest is beginning to pupate. Crows and other birds that have been observed preying upon the larvæ should not be scared away nor trapped nor killed.

5. All intermediate host plants near the abacá and coconut plantations, such as the wild palms and other trees should be destroyed and the plantations should be kept free from noxious weeds, especially those of the grass family.

SUMMARY AND CONCLUSIONS

1. The larva of the slug caterpillar, *Thosea sinensis* Wlk. is a destructive pest of the abacá and coconuts.

2. The pest is widely distributed in the Islands from the Island of Luzon to Mindanao and is present wherever there are coconuts.

3. The larva has several host plants, among them are abacá, coconut, wild palms, banana, sugar cane, corn, wild grasses, and "anonang." Of the abacá, the Maguindanao variety is not so susceptible.

4. The pest is able to defoliate both abacá and coconut plants, but the abacá recovers faster than coconuts because of its fast growth.

5. The life cycle from egg to adult stage varies from 78 to 102 days or an average of about 90 days. During a year, therefore, three or four generations are possible.

6. The moths are nocturnal in habit. The females have been found to lay from 144 to 508 eggs, with an average of 315.

7. The adults do not live long in confinement. The longevity records are from 2 to 14 days or an average of 5 days.

8. In the field about 95 per cent of the eggs hatch and no parasites have been observed.

9. The proportion of males and females is about fifty-fifty.

10. The larvæ are parasitized by two species of Braconids and one species of Tachina fly. They are also preyed upon by a species of sting bug, *Canthecona furcellata* Wolff.

11. Crows and monkeys also eat the larvae and the pupae are hunted by chickens.

12. Under field conditions, only about 50 per cent of the pupae develop into adults because they are attacked by parasites and other enemies.

13. The larvæ of the pest are killed by a soap solution spray. One part of soap to about 20 to 60 parts water have been found effective depending, upon the sizes of the larvæ.

14. The soap solution when sprayed on the leaves of abacá produces no burning effect. But when the soap is mixed with calcium arsenate to act both as stomach and contact poisons, the mixture produced burning effect on the leaves.

15. The flowers of the cover crop, *Calopogonium mucanoides*, serve as one of the hosts of the adults Branconid parasites, especially the smaller species.

REFERENCES

1. Comstock, G. F. A Manual of the Study of Insects, Ninth Edition, Ithaca, New York, 1910.
2. Banks, C. S. The Principal Insect Injuring the Coconut Palm (Part I), Philippine Journal of Science, Vol. I, No. 2, pp. 216–217. Manila, 1906.
3. Hampson, G. F. The Fauna of British India, Moths, Vol. I, pp. 371–402. London, 1892.

ILLUSTRATIONS

PLATE I. Different stages of the life cycle of *Thosea sinensis* Walker.
II. Two of the natural enemies (parasites) of the catepillar *Thosea sinensis* Wlk. and a diagramatic drawing of a top of abacá plant showing the effect of soap and calcium arsenate spray.
III. (*a*) A view of a seriously infested abacá plantation.
(*b*) A young coconut seriously infested.
IV. (*a*) A close-up of the infested abacá plants.
(*b*) A young abacá infected.
V. (*a*) A view of a recovered abacá plantation.
(*b*) One species of the wild palms, a host of the pest.
VI. (*a*) Another view of the recovered abacá plants.
(*b*) A Bean sprayer hitched to a home-made sled to facilitate getting it through an abacá plantation.

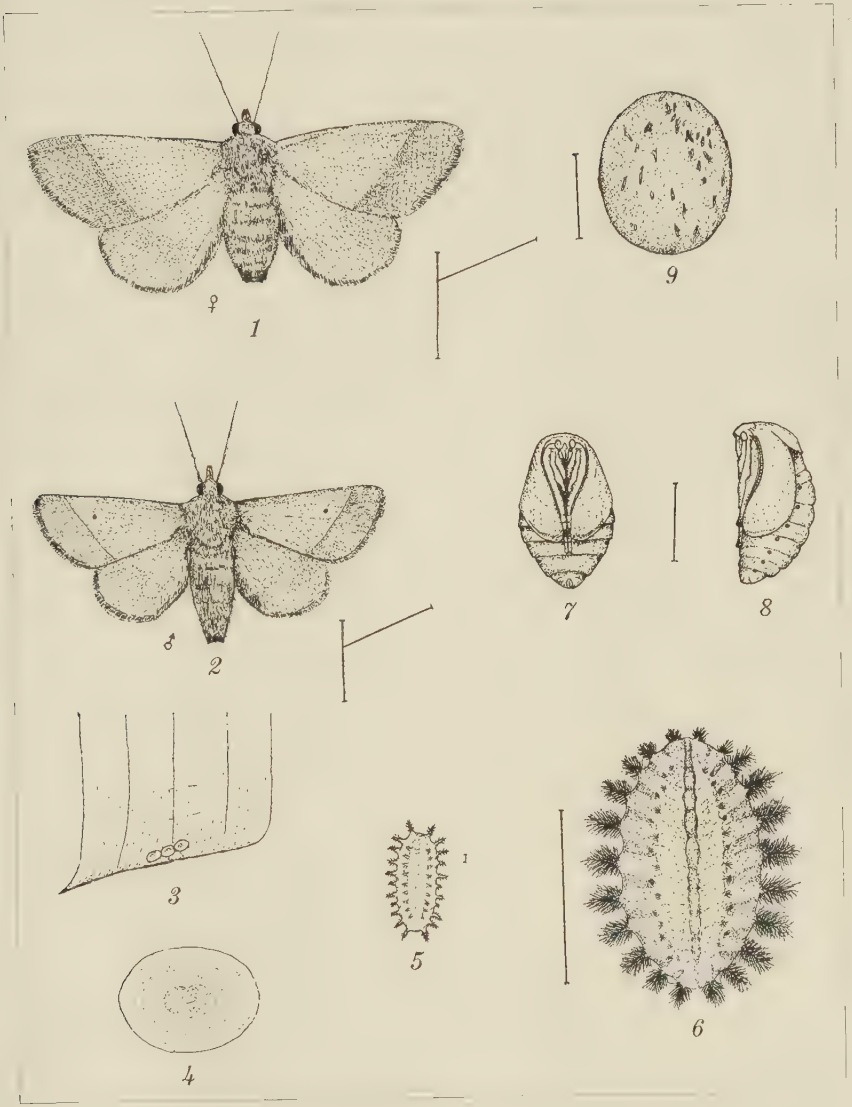

PLATE I. Different stages of the life cycle of *Thosea sinensis* Walker. Drawings enlarged. (1) Female adult; (2) male adult; (3) eggs on abaca leaf, natural size; (4) egg enlarged. Note the forming larva at the center; (5) newly formed larva; (7 and 8) pupae, ventral and lateral views; and (9) cocoon.

1

4

2

5

3

6

PLATE II. Two of the natural enemies (parasites) of the slug caterpillar, *Thosea sinensis* Walker. Drawings enlarged. (1) portion of larva with eggs of the fly parasite; (2) adult fly parasite; (3) diagrammatic drawing of the cocoon with the empty cocoon of the fly parasite; (4) an adult of the brachonid parasite, small species; (5) a larva mummified as a result of the attack of the parasites. Note the cotton-like mass of cocoons beneath the dead larva with minute exit holes; (6) a diagrammatic drawing of the upper portion of the abaca plant showing the effect of the soap and calcium arsenate spray—drawing much reduced.

(*a*) A view of a seriously infested abaca plantation. Talomo, Davao

(*b*) A young coconut tree seriously infested by the pest. Talomo, Davao

PLATE III

(*a*) A close-up of the infested abaca plants. Talomo, Davao

(*b*) A young abaca infested by the pest. Ohta Development Co. Bago, Davao

PLATE IV

(*a*) A view of a plantation which has recovered from a serious attack of the pest

(*b*) One of the species of wild palms which is also a host of the pest

PLATE V

(*a*) Another view of abaca plants that have recovered from the attack of the pest. Note the dried bladeless petioles forming a network inside the plantation

(*b*) A bean sprayer hitched to a home-made sled to drag it through an abaca plantation

PLATE VI

EXPERIMENTS ON CIGARETTE TOBACCO PRODUCTION DURING THE 1931–1932 SEASON

By Domingo B. Paguirigan

Agronomist, Bureau of Plant Industry

and

Jose C. Ramos

Assistant Agronomist, Bureau of Plant Industry

The total importations of tobacco into the Philippines in 1929, 1930, and 1931 were valued at ₱6,541,455, ₱5,887,775 and ₱5,443,428 respectively, of which ₱4,283,666, ₱4,121,739 and ₱4,093,381 corresponded to importations of cigarettes and cigarette leaf tobacco or 66 per cent, 70 per cent, and 75 per cent of the total, respectively.

Table I shows the quantities and values of Philippine imports of cigarettes during the period from 1918 to 1931, inclusive, and the quantities and values of Philippine imports of cigarette leaf tobacco during the period from 1923 to 1931, inclusive. The combined values of Philippine imports of cigarette leaf tobacco and cigarettes during the period from 1923 to 1931, inclusive, are also shown.

Table I.—*Quantities and values of Philippine imports of cigarettes and cigarette leaf tobacco*

Year	Cigarettes		Cigarette leaf tobacco		Total values
	Quantity	Value	Quantity	Value	
	Kilos	*Pesos*	*Kilos*	*Pesos*	*Pesos*
1918	59,150,200	460,246	.....	.....	460,246
1919	71,919,152	654,793	.....	.....	654,793
1920	128,747,849	1,217,353	.....	.....	1,217,353
1921	230,584,977	2,176,229	.....	.....	2,176,229
1922	154,808,204	1,102,400	.....	.....	1,102,400
1923	190,615,514	1,033,989	10,245	96,386	1,130,375
1924	241,233,531	1,268,542	5,147	19,770	1,288,312
1925	361,563,567	1,705,987	17,662	13,054	1,719,041
1926	417,971,211	1,920,743	34,636	60,626	1,981,369
1927	542,091,580	2,641,561	129,456	156,880	2,798,441
1928	709,003,161	3,268,100	119,166	107,984	3,376,084
1929	1,019,837,676	4,251,798	40,585	31,868	4,283,666
1930	1,075,763,726	4,064,032	65,404	57,706	4,121,738
1931	1,131,976,869	3,817,313	358,534	276,068	4,093,381

We note from Table I that it was only in 1920 that the importation of cigarettes reached the ₱1,000,000 mark. In 1921,

it virtually doubled and then returned to ₱1,000,000 the following year. From the year 1922, however, it persisted in climbing so that in 1929, it was beyond the ₱4,000,000 mark. To date the yearly importations have remained practically the same in value, no doubt because of the depression, but the quantity has continued to increase regularly.

The importation of cigarette leaf tobacco only began in 1923 and, while since 1930 the quantities imported yearly have been insignificant, in 1931 the value suddenly passed the ₱250,000 mark. This was the result of the successful attempt on the part of three local factories to manufacture aromatic cigarettes locally. And this hardly helps the Philippine tobacco industry, since the raw materials used are imported.

Inasmuch as the main problem we have in the manufacture of aromatic cigarettes in the Philippines is the production of suitable raw materials, it is deemed opportune, notwithstanding the fact that many of the experiments are still in progress, to sumbit herewith a report on the experiments on cigarette tobacco production conducted during the tobacco season (1931–1932) that has just ended.

In this report the discussion of the literature on the subject and of the principles involved are omitted inasmuch as they were taken up in the first progress report on the experiments, entitled, "Experiments on Cigarette Tobacco Production in the Cagayan Valley, 1925–1929." In the present report the words "Cagayan Valley" have been omitted because the experiments were carried on in different regions, namely; Isabela, La Union, Pangasinan, Nueva Ecija, Iloilo, and Rizal Provinces.

Because the Provinces of La Union, Pangasinan, Nueva Ecija, Iloilo, and Rizal belong to the same Philippine climatic type (First type) consisting of two pronounced seasons, dry in winter and spring and wet in summer and autumn and because most of the experiments were performed in Rizal, that is, at the Alabang Rice Station, only the data obtained at this station are considered in the present report.

The climate of Isabela belongs to the Third or Intermediate type, in which there is no maximum rain period but the dry season is short, lasting only from one to three months. The experiments in Isabela as usual were conducted at the Ilagan Tobacco Station.

Thus the present report has a new feature, a comparison of two Philippine regions each representing a different Philippine climatic type. Furthermore because of peculiar conditions pre-

vailing in both regions, there are also differences followed in the experimental procedure. And because of these facts, the results are treated separately for each place or region.

EXPERIMENTS CONDUCTED AT THE ILAGAN TOBACCO STATION

Soil used.—The soil used in this experiment runs from silty loam to clay loam. In the previous years the land was planted to tobacco and occasionally to corn and some leguminous plants. This land was adjacent to the land that the senior author used in 1925–1929 in his cigarette tobacco experiments, which was found to have the following original analysis. (See Table II.)

TABLE II.—*Mechanical and chemical analysis of field B, lot 2, Ilagan Tobacco Station, in 1925 (Water free basis).*

Mechanical		Chemical	
Detritus not passing	0.0	Loss in ignition	9.11
Coarse sand	0.0	Nitrogen (N_2)	0.081
Medium sand	0.1	Phosphoric anhydride (P_2O5)	0.181
Fine sand	3.8	Lime (CaO)	2.08
Very fine sand	8.6	Potash (K_2O)	0.468
Silt	76.4	Humus	0.35
Clay	11.1	Soil acidity	0.007
Total	100 0		

Climatic conditions.—The weather conditions at the Ilagan Tobacco Station while the experiment was being conducted are given in Table III.

TABLE III.—*Mean monthly temperature, precipitation, and relative humidity at the Ilagan Tobacco Station during the tobacco season 1931–1932.*

Month	Mean temperature	Rainfall	Relative humidity
	°C	mm.	Per cent
September	27.85	301.3	79.10
October	26.32	396.4	87.30
November	25.40	618.9	83.09
December	23.99	315.0	80.60
January	21.75	66.1	82.00
February	24.35	22.8	76.17
March	25.22	55.1	75.40
April	27.93	26.1	73.26

Variety used.—The acclimatized foreign cigarette tobacco varieties *North Carolina Bright Yellow, While Burley, Samsoun Bafra, Orinoco,* and *Adcock,* were used.

Sowing of seed.—Two sowings were done at an interval of one week, the first being on October 12, and the second October 17, 1931, on well pulverized seed beds protected from the rain

by a shed made of bamboo and nipa, raised about one meter high from the ground. The size of each seed bed was 1.2 meters wide and 12 meters long. Two days before sowing the seed, one kilogram of ammonium sulphate fertilizer was applied to each seed bed. The seed was sown at the rate of 6 grams for every seed bed. The seed beds were watered whenever it was found necessary. When the seedlings were about two weeks old they were thinned and pricked leaving them about 5 centimeters apart.

Preparation of the land.—Just before the first plowing was done all the weeds growing in the field were cut down with bolos and piled along the edges of the land. When they were sufficiently dry they were burned. The land was plowed and harrowed twice before it was planted.

Transplanting.—The seedlings were transplanted December 12, 1931, by the native method. They were exactly two months old at that time. The planting distance was 70 centimeters between the plants and 80 centimeters between the rows. Each of the five varieties was planted in ten replications in plots with a size of 10 by 15 meters each.

Cultivation.—Two kinds of implements were used for cultivation, the Vargas plow and a four-tooth cultivator. As the soil was quite compact and weedy a Vargas plow drawn by a carabao was passed between the rows twice so as to loosen the soil. Immediately after this the cultivator was used in the same way in order to break the clods and at the same time to kill the weeds. The first cultivation was accomplished two weeks after the seedlings were set out in the field. The second or last cultivation was done two weeks later.

Control of pests and diseases.—For controlling the tobacco worms both hand picking and calcium arsenate dust (one part calcium arsenate mixed with 16 parts fine road dust by weight) were used simultaneously.

The plant lice, which were quite abundant at that time, were successfully controlled by spraying the plants with Black leaf 40. The spray was prepared by mixing 200 cubic centimeters of Black Leaf 40 in 5 gallons (one petroleum can) of water.

All the plants in the field found with symptoms of mosaic, root-rot, and other similar diseases were simply pulled up and burned as soon as they were discovered.

Harvesting.—The leaves were harvested one by one as they matured. Harvesting was begun in March 5, and lasted until April 26, 1932.

Curing tests.—Two methods of curing the leaves were used; (1) sun curing and (2) flue-curing. Immediately after harvesting the leaves, they were brought to the camarin for poling or stringing. Because of the small sizes of the leaves the string was found more convenient to use than the native palillo. In a piece of string, about 1.2 meters long exactly 100 leaves were strung singly by passing the needle through the petiole of the leaves. The string was attached to both ends of a bamboo pole of about the same length and about 5 centimeters in diameter.

1. *Sun curing experiments.*—A bamboo framework about 1.5 meters above the ground was constructed in the open where the leaves were hung for curing in the sun. The leaves were kept outside from about 6 o'clock in the morning to about 5 o'clock in the afternoon. At night they were kept inside the camarin so they would not get wet in case it rained. The process was continued until the leaves were completely dry.

In the sun curing test the leaves were divided into three groups as follows:

(1) The leaves in the first group were cured completely inside the camarin (check).

(2) The leaves in the second group were first kept hanging inside the camarin until they became yellow and then dried in the sun.

(3) The leaves in the third group were completely cured in the sun.

2. *Flue-curing experiments.*—A flue-curing barn was constructed for this purpose. Because the heating of this barn is different from that of the experimental curing box devised by the senior author in 1929, and because the flues of the barn are cast iron whereas those of the box were galvanized iron, five methods of heating the barn were tried. Perhaps more might have been tried were it not for the limited capacity of the barn. The methods differed only in the length of time the leaves were cured and the range in which the temperature was raised. In starting the fire 28° C. was always made as the starting temperature. To be able to do this the firing was always started late in the afternoon except the first trial which was started in the morning. Before the fire was started all the necessary fuel for one operation was gathered near the barn, because once it was started it was kept going day and night until all the leaves were thoroughly dry. For every method three men were employed, each working an eight-hour shift. A guide for raising the temperature was placed inside the barn. Together with

this were a thermometer, and an instrument for measuring the relative humidity. The temperature reading inside the barn was taken every hour. The man watching the barn was required to observe that it conformed to the given outline. In case the temperature was rising too fast he had to reduce the fire. On the other hand if the temperature was lower the fire had to be increased.

In all the methods when the leaves were about to reach the yellow stage the two windows of the barn were kept open so as to have a free circulation of air inside the barn. This was found necessary in order to prevent rapid drying of the leaves before the yellow stage was reached.

The leaves were quite brittle after curing and would not stand even careful handling so that it was found necessary to open the windows and door of the barn over night at least, to make the leaves pliable before they were taken out for bundling. The results of this experiment are given in Table IV.

TABLE IV.—*The different methods of flue-curing experiments at the Ilagan Tobacco Station*

METHOD NO. 1

Date	Time	Hour No.	Temperature	Remarks and observations
1932			°C.	
March 5	10.00 a. m.	1	28	The temperature was maintained at 51° C. until all the leaves became dry. It took another 24 hours to do this.
Do.	11.00 a. m.	2	28	
Do.	12.00 a. m.	3	28	
Do.	1.00 p. m.	4	29	
Do.	2.00 p. m.	5	29	
Do.	3.00 p. m.	6	29	
Do.	4.00 p. m.	7	30	Only about 25 per cent of the leaves turned yellow. After a few days they turned dark brown. This shows that at 51° C. the color could not be fixed.
Do.	5.00 p. m.	8	30	
Do.	6.00 p. m.	9	30	
Do.	7.00 p. m.	10	31	
Do.	8.00 p. m.	11	31	
Do.	9.00 p. m.	12	31	
Do.	10.00 p. m.	13	32	
Do.	11.00 p. m.	14	32	
Do.	12.00 p. m.	15	32	
March 6	1.00 a. m.	16	33	Among the five varieties used in this method the *Adcock* and *North Carolina Bright Yellow* gave better results than the other varieties.
Do.	2.00 a. m.	17	34	
Do.	3.00 a. m.	18	35	
Do.	4.00 a. m.	19	36	
Do.	5.00 a. m.	20	37	
Do.	6.00 a. m.	21	38	
Do.	7.00 a. m.	22	38	
Do.	8.00 a. m.	23	38	
Do.	9.00 a. m.	24	38	
Do.	10.00 a. m.	25	40	
Do.	11.00 a. m.	26	42	
Do.	12.00 a. m.	27	44	
Do.	1.00 p. m.	28	45	
Do.	2.00 p. m.	29	46	
Do.	3.00 p. m.	30	47	
Do.	4.00 p. m.	31	48	
Do.	5.00 p. m.	32	49	
Do.	6.00 p. m.	33	50	
Do.	7.00 p. m.	34	51	

Yield.—The data on yield were taken after the leaves had been cured. They were carefully weighed and recorded, then computed on the basis of one hectare. They are given in Table V.

TABLE V.—*Yield of cigarette tobacco varieties at the Ilagan Tobacco Station, 1931–1932*

METHOD NO. 2

Date	Time	Hour No.	Temperature	Remarks and observations
1932			°C.	
March 14	6.00 p. m.	1	28	
Do.	7.00 p. m.	2	28	
Do.	8.00 p. m.	3	28	
Do.	9.00 p. m.	4	29	
Do.	10.00 p. m.	5	29	
Do.	11.00 p. m.	6	29	
Do.	12.00 p. m.	7	30	
March 15	1.00 a. m.	8	30	
Do.	2.00 a. m.	9	30	
Do.	3.00 a. m.	10	30	
Do.	4.00 a. m.	11	31	
Do.	5.00 a. m.	12	31	
Do.	6.00 a. m.	13	31	
Do.	7.00 a. m.	14	32	
Do.	8.00 a. m.	15	32	
Do.	9.00 a. m.	16	32	
Do.	10.00 a. m.	17	33	
Do.	11.00 a. m.	18	33	
Do.	12.00 a. m.	19	34	
Do.	1.00 p. m.	20	34	
Do.	2.00 p. m.	21	35	
Do.	3.00 p. m.	22	35	
Do.	4.00 p. m.	23	36	
Do.	5.00 p. m.	24	36	
Do.	6.00 p. m.	25	37	
Do.	7.00 p. m.	26	37	
Do.	8.00 p. m.	27	38	
Do.	9.00 p. m.	28	38	
Do.	10.00 p. m.	29	38	
Do.	11.00 p. m.	30	39	
Do.	12.00 p. m.	31	39	
March 16	1.00 a. m.	32	40	
Do.	2.00 a. m.	33	40	
Do.	3.00 a. m	34	41	
Do.	4.00 a. m.	35	41	
Do.	5.00 a. m.	36	42	
Do.	6.00 a. m.	37	42	
Do.	7.00 a. m.	38	43	
Do.	8.00 a. m.	39	43	
Do.	9.00 a. m.	40	44	
Do.	10.00 a. m.	41	44	
Do.	11.00 a. m.	42	45	The firing was stopped 12 hours later.
Do.	12.00 a. m.	43	45	
Do.	1.00 p. m.	44	46	This method gave a more satisfactory result than the first trial.
Do.	2.00 p. m.	45	47	
Do.	3.00 p. m.	46	47	
Do.	4.00 p. m.	47	48	
Do.	5.00 p. m.	48	48	About 50 per cent of the leaves turned yellow. Some of the leaves, however, were speckled with brown spots as most of the leaves were already overriped when they were harvested.
Do.	6.00 p. m.	49	49	
Do.	7.00 p. m.	50	49	
Do.	8.00 p. m.	51	50	
Do.	9.00 p. m.	52	50	
Do.	10.00 p. m.	53	51	
Do.	11.00 p. m.	54	51	
Do.	12.00 p. m.	55	52	
March 17	1.00 a. m.	56	52	
Do.	2.00 a. m.	57	53	
Do.	3.00 a. m.	58	53	
Do.	4.00 a. m.	59	54	With reference to this method it seemed that by the temperature dragging or raising it very gradually it induced the leaves to become yellow.
Do.	5.00 a. m.	60	54	
Do.	6.00 a. m.	61	55	
Do.	7.00 a. m.	62	55	
Do.	8.00 a. m.	63	56	

TABLE V.—*Yield of cigarette tobacco varieties at the Ilagan Tobacco Station, 1931–1932*—Continued

METHOD NO. 2—Continued

Date	Time	Hour No.	Temperature	Remarks and observations
1932			°C.	
March 17	9.00 a. m.	64	56	
Do.	10.00 a. m.	65	57	
Do.	11.00 a.m.	66	57	
Do.	12.00 a. m.	67	58	
Do.	1.00 p. m.	68	58	It was also observed that the cured leaves did not change in color. This shows that the color can be fixed at 66° C.
Do.	2.00 p. m.	69	59	
Do.	3.00 p. m.	70	59	
Do.	4.00 p. m.	71	60	
Do.	5.00 p. m.	72	60	
Do.	6.00 p. m.	73	61	
Do.	7.00 p. m.	74	61	
Do.	8.00 p. m.	75	62	
Do.	9.00 p. m.	76	62	
Do.	10.00 p. m.	77	63	
Do.	11.00 p. m.	78	64	
Do.	12.00 p. m.	79	64	
March 18	1.00 a. m.	80	65	
Do.	2.00 a. m.	81	65	
Do.	3.00 a. m.	82	66	

METHOD NO. 3

Date	Time	Hour No.	Temperature	Remarks and observations
1932			°C.	
March 28	6.00 p. m.	1	28	
Do.	7.00 p. m.	2	28	
Do.	8.00 p. m.	3	28	
Do.	9.00 p. m.	4	29	
Do.	10.00 p. m.	5	29	
Do.	11.00 p. m.	6	29	
Do.	12.00 p. m.	7	30	
March, 29	1.00 a. m.	8	30	
Do.	2.00 a. m.	9	30	
Do.	3.00 a. m.	10	31	
Do.	4.00 a. m.	11	31	
Do.	5.00 a. m.	12	31	
Do.	6.00 a. m.	13	32	
Do.	7.00 a. m.	14	32	
Do.	8.00 a. m.	15	32	
Do.	9.00 a. m.	16	33	
Do.	10.00 a. m.	17	33	
Do.	11.00 a. m.	18	33	
Do.	12.00 a. m.	19	34	
Do.	1.00 p. m.	20	34	
Do.	2.00 p. m.	21	34	
Do.	3.00 p. m.	22	35	
Do.	4.00 p. m.	23	35	
Do.	5.00 p. m.	24	35	
Do.	6.00 p. m.	25	36	
Do.	7.00 p. m.	26	36	
Do.	8.00 p. m.	27	36	
Do.	9.00 p. m.	28	37	
Do.	10.00 p. m.	29	37	
Do.	11.00 p. m.	30	37	
Do.	12.00 p. m.	31	38	
March, 30	1.00 a. m.	32	38	
Do.	2.00 a. m.	33	38	
Do.	3.00 a. m.	34	38	
Do.	4.00 a. m.	35	39	
Do.	5.00 a. m.	36	39	
Do.	6.00 a. m.	37	40	
Do.	7.00 a. m.	38	40	In this method leaves of three different degrees of ripeness were used, namely, dark green leaves; light green leaves with light shade of yellow; and leaves with yellowish tips and margins.
Do.	8.00 a. m.	39	41	
Do.	9.00 a. m.	40	41	
Do.	10.00 a. m.	41	42	
Do.	11.00 a. m.	42	42	
Do.	12.00 a. m.	43	43	
Do.	1.00 p. m.	44	43	

TABLE V.—*Yield of cigarette tobacco varieties at the Ilagan Tobacco Station, 1931–1932*—Continued

METHOD NO. 3—Continued

Date	Time	Hour No.	Temperature	Remarks and observations
1932			°C.	
March 30	2.00 p. m.	45	44	
Do.	3.00 p. m.	46	44	
Do.	4.00 p. m.	47	45	
Do.	5.00 p. m.	48	45	
Do.	6.00 p. m.	49	46	
Do.	7.00 p. m.	50	46	Those leaves which were dark green in the field when harvested turned also greenish after curing; the light green leaves turned yellowish; and the leaves with yellowish tips and margins became dark brown.
Do.	8.00 p. m.	51	47	
Do.	9.00 p. m.	52	47	
Do.	10.00 p. m.	53	48	
Do.	11.00 p. m.	54	48	
Do.	12.00 p. m.	55	49	
March, 31	1.00 a. m.	56	49	
Do.	2.00 a. m.	57	50	
Do.	3.00 a. m.	58	50	
Do.	4.00 a. m.	59	51	
Do.	5.00 a m.	60	52	
Do.	6.00 a. m.	61	53	
Do.	7.00 a. m.	62	54	
Do.	8.00 a. m.	63	55	
Do.	9.00 a. m.	64	56	
Do.	10.00 a. m.	65	57	
Do.	11.00 a. m.	66	58	
Do.	12.00 a. m.	67	59	
Do.	1.00 p. m.	68	60	
Do.	2.00 p. m.	69	61	
Do.	3.00 p. m.	70	62	
Do.	4.00 p. m.	71	63	
Do.	5.00 p. m.	72	64	
Do.	6.00 p. m.	73	65	
Do.	7.00 p. m.	74	66	

METHOD NO. 4

Date	Time	Hour No.	Temperature	Remarks and observations
1932			°C.	
March, 12	4.00 p. m.	1	28	
Do.	5.00 p. m.	2	28	
Do.	6.00 p. m.	3	28	
Do.	7.00 p. m.	4	29	
Do.	8.00 p. m.	5	29	
Do.	9.00 p. m.	6	29	
Do.	10.00 p. m.	7	30	
Do.	11.00 p. m.	8	30	
Do.	12.00 p. m.	9	30	
March, 13	1.00 a. m.	10	31	
Do.	2.00 a. m.	11	31	
Do.	3.00 a. m.	12	31	
Do.	4.00 a. m.	13	32	
Do.	5.00 a. m.	14	32	
Do.	6.00 a. m.	15	32	
Do.	7.00 a. m.	16	33	
Do.	8.00 a. m.	17	33	
Do.	9.00 a. m.	18	33	
Do.	10.00 a. m.	19	34	
Do.	11.00 a. m.	20	34	
Do.	12.00 a. m.	21	34	
Do.	1.00 p. m.	22	35	
Do.	2.00 p. m.	23	35	
Do.	3.00 p. m.	24	35	
Do.	4.00 p. m.	25	36	
Do.	5.00 p. m.	26	36	
Do.	6.00 p. m.	27	37	
Do.	7.00 p. m.	28	37	
Do.	8.00 p. m.	29	38	
Do.	9.00 p. m.	30	38	
Do.	10.00 p. m.	31	38	
Do.	11.00 p. m.	32	38	
Do.	12.00 p. m.	33	39	

TABLE V.—*Yield of cigarette tobacco varieties at the Ilagan Tobacco Station, 1931–1932*—Continued

METHOD NO. 4—Continued

Date	Time	Hour No.	Temperature	Remarks and observations
1932			°C.	
March, 14	1.00 a. m.	34	39	
Do.	2.00 a. m.	35	40	
Do.	3.00 a. m.	36	40	
Do.	4.00 a. m.	37	41	
Do.	5.00 a. m.	38	41	
Do.	6.00 a. m.	39	42	As the temperature could not be raised higher than 61° C. the the heat was maintained at that temperature until all the leaves became sufficiently dry. The reason for not being able to reach 66° C. although the original outline called for it was due to the fact that the fuel used was of a poor kind.
Do.	7.00 a. m.	40	42	
Do.	8.00 a. m.	41	43	
Do.	9.00 a. m.	42	43	
Do.	10.00 a. m.	43	44	
Do.	11.00 a. m.	44	44	
Do.	12.00 a. m.	45	45	
Do.	1.00 p. m.	46	45	
Do.	2.00 p. m.	47	46	
Do.	3.00 p. m.	48	46	
Do.	4.00 p. m.	49	47	
Do.	5.00 p. m.	50	47	
Do.	6.00 p. m.	51	48	
Do.	7.00 p. m.	52	48	
Do.	8.00 p. m.	53	49	
Do.	9.00 p. m.	54	49	
Do.	10.00 p. m.	55	50	
Do.	11.00 p. m.	56	50	In this method however, about 50 per cent of the leaves turned yellow but after a few days they turned brownish, showing that drying the leaves at 61° C. will not fix the color, This was specially true with the *Orinoco* variety.
Do.	12.00 p. m.	57	51	
March, 15	1.00 a. m.	58	51	
Do.	2.00 a. m.	59	52	
Do.	3.00 a. m.	60	53	
Do.	4.00 a. m.	61	53	
Do.	5.00 a. m.	62	54	
Do.	6.00 a. m.	63	54	
Do.	7.00 a. m.	64	55	
Do.	8.00 a. m.	65	55	
Do.	9.00 a. m.	66	56	
Do.	10.00 a. m.	67	56	
Do.	11.00 a. m.	68	57	
Do.	12.00 a. m.	69	57	
Do.	1.00 p. m.	70	58	
Do.	2.00 p. m.	71	58	
Do.	3.00 p. m.	72	59	
Do.	4.00 p. m.	73	59	
Do.	5.00 p. m.	74	60	
Do.	6.00 p. m.	75	60	
Do.	7.00 p. m.	76	61	

METHOD NO. 5

Date	Time	Hour No.	Temperature	Remarks and observations
1932			°C.	
March, 26	6.00 p. m.	1	28	
Do.	7.00 p. m.	2	28	
Do.	8.00 p. m.	3	28	
Do.	9.00 p. m.	4	30	
Do.	10.00 p. m.	5	30	
Do.	11.00 p. m.	6	30	
Do.	12.00 p. m.	7	32	
March, 27	1.00 a. m.	8	32	
Do.	2.00 a. m.	9	32	
Do.	3.00 a. m.	10	32	
Do.	4.00 a. m.	11	32	
Do.	5.00 a. m.	12	35	
Do.	6.00 a. m.	13	35	
Do.	7.00 a. m.	14	35	
Do.	8.00 a. m.	15	35	
Do.	9.00 a. m.	16	35	
Do.	10.00 a. m.	17	35	
Do.	11.00 a. m.	18	38	
Do.	12.00 a. m.	19	38	
Do.	1.00 p. m.	20	38	
Do.	2.00 p. m.	21	38	

TABLE V.—*Yield of cigarette tobacco varieties at the Ilagan Tobacco Station, 1931–1932*—Continued

METHOD NO. 5—Continued

Date	Time	Hour No.	Temperature	Remarks and observations
1932			°C.	
March 27.	3.00 p. m.	22	38	
Do.	4.00 p. m.	23	38	
Do.	5.00 p. m.	24	39	
Do.	6.00 p. m.	25	40	
Do.	7.00 p. m.	26	41	The temperature was maintained at 66° C. until the leaves were completely dry.
Do.	8.00 p. m.	27	42	
Do.	9.00 p. m.	28	43	
Do.	10.00 p. m.	29	44	
Do.	11.00 p. m.	30	45	
Do.	12.00 p. m.	31	46	
April, 28.	1.00 a. m.	32	47	In this method almost 90 per cent of the leaves became dry before the yellow stage was reached. It simply shows that the heat was raised too rapidly.
Do.	2.00 p. m.	33	48	
Do.	3.00 a. m.	34	48	
Do.	4.00 a. m.	35	48	
Do.	5.00 a. m.	36	48	
Do.	6.00 a. m.	37	48	
Do.	7.00 a. m.	38	48	
Do.	8.00 a. m.	39	48	
Do.	9.00 a. m.	40	48	
Do	10.00 a. m.	41	50	
Do.	11.00 a. m.	42	52	The senior author, however, in 1929 obtained satisfactory results with this outline in his flue-curing box experiments.
Do.	12.00 a. m.	43	54	
Do.	1.00 p. m.	44	56	
Do.	2.00 p. m.	45	58	
Do.	3.00 p. m.	46	60	
Do.	4.00 p. m.	47	62	
Do.	5.00 p. m.	48	64	
Do.	6.00 p. m.	49	66	
Do.	7.00 p. m.	50	66	

Variety name	Yield per hectare in kilos
Orinoco	466.5
White Burley	277.9
Adcock	424.0
North Carolina	179.8
Bright Yellow	
Samsoun Bafra	173.9

EXPERIMENTS CONDUCTED AT THE ALABANG RICE STATION

Soil used.—The land used in this experiment had been planted to tomatoes for the last two years. The soil is clay. It is rather heavy during the dry season, and due to the lack of moisture, it cracked. The analysis of the soil used at this station is given in Table VI.

TABLE VI.—*Mechanical and chemical analysis of Alabang soil*

Mechanical		Chemical	
Detritus not passing mm. sieve	0.2	Nitrogen (N_2)	0.090
Coarse sand	0.6	Phosphoric anhydride (P_2O_5)	0.097
Medium sand	2.3	Lime (CaO)	2.09
Fine sand	8.0	Potash (K_2O)	0.731
Very fine sand	6.9	Humus	0.49
Silt	48.8	Acidity ($CaCO_3$)	
Clay	33.4		
Total	100.0		

Climatic conditions.—The weather conditions for the 1931–1932 season at the Alabang Rice Station are given in Table VII.

TABLE VII.—*Climatic conditions at the Alabang Rice Station for the 1931–1932 season*

Months	Temperature	Rainfall	Relative humidity
	°C.	mm.	Per cent
September	23.6	258.0	83.6
October	23.15	209.4	85.0
November	22.65	188.6	84.1
December	22.3	99.4	78.7
January	[a] 19.1	1.1	73.0
February	[a] 19.8	.9	69.5
March	[a] 21.1	5.4	66.4
April	[a] 23.3	0.5	63.7

[a] From January to April, 1932, only the minimum temperature is available.

Varieties used.—The varieties *Adcock, Conqueror, Big Warne, Warne, Longleaf Gooch, North Carolina Bright Yellow, White Stem Orinoco,* and *Goldleaf* were used.

Sowing of seed.—Because of the heavy texture of the original seed bed soil it was found necessary to change the surface soil to a depth of about ten centimeters for a much lighter and humic soil which was taken from a bamboo groove nearby. After the seed beds had been thoroughly worked and provided with a nipa cover, the seed was sown on October 14, 1931, at the rate of about one gram for every square meter of seed bed. Since the distribution of the seedlings in the seed bed was not very uniform thinning and pricking was practiced.

Preparation of the land.—The land preparation consisted in plowing and harrowing the land two times.

Transplanting.—Transplanting was done December 18, 1931, at a distance of 70 by 80 centimeters. The land was fertilized by placing a handful of stable manure in each hole in which a seedling was set.

Cultivation.—After setting the plants in the field no cultivation was given except that two weeks after transplanting the soil around each plant was pulverized once at the surface with a hand trowel.

Control of Pests and Diseases.—For controlling the tobacco worms nothing was done except picking them off by hand occasionally.

Topping experiments.—In order to determine the effect of topping on the color and yield of cigarette tobacco an equal number of plants were topped and untopped for each variety. Topping was done as soon as the flower heads began to appear.

The height of topping was about ten centimeters from the tip of the flower head. In determining the yield all the topped and untopped leaves for each variety were weighed separately. The percentage of yellow leaves was found by selecting all the yellow leaves and then the weight was taken. The results are given in Table VIII.

TABLE VIII.—*Effect of topping on the color and yield of cigarette tobacco*

Variety name	Weight of leaves per hectare in kilos			Percentage of yellow leaves	
	Check	Topped	Difference in weight	Check	Topped
Adcock	2,142.84	1,586.23	556.50	10	42
Conqueror	999.99	892.85	107.14	73	47
Big Warne	1,339.27	595.17	744.10	50	44
Warne	773.74	684.45	89.28	62	59
White Stem Orinoco	863.02	714.28	148.74	27	55
Goldleaf	1,160.70	803.56	357.14	33	53

Irrigation experiments.—Because of the limited number of plants produced for this experiment, the plants used as a check in the topping experiments were also used as a check for this experiment. In obtaining the data on the effect of irrigation on the color and yield, the same procedure used in the topping experiments was followed.

Just a week after transplanting a certain number of rows in each variety, were irrigated three times a week. The irrigation water was taken from a water pipe installed near the experimental field. Irrigation was done by allowing the water to run along the furrows until the soil was saturated. The results of this experiment are given in Table IX.

TABLE IX.—*Effect of irrigation on the color and yield of cigarette tobacco*

Variety name	Weight of leaves per hectare in kilos			Percentage of yellow leaves	
	Check	Irrigated	Difference in weight	Check	Irrigated
Adcock	2,142.84	1,309.45	833.38	10	48
Conqueror	999.99	892.85	107.14	73	44
Big Warne	1,339.27	589.28	749.99	50	50
Warne	773.74	803.56	29.82	62	56
White Stem Orinoco	863.02	714.28	148.74	27	54
Gold leaf	1,160.70	803.56	357.14	33	53

Curing experiments.—Four methods of curing were tested in this study. They are: (1) complete sun curing, (2) curing under a galvanized iron roof, (3) curing by placing the leaves first in the shade (camarín) until they become yellow, then in

the sun until they are dry, and (4) complete curing inside the camarin. The results are given in Table X.

TABLE X.—*Effect of different methods of curing on the color of the leaves*

Variety name	Sun curing	Curing under galvanized iron roof	Leaves first placed inside the camarin then in the sun	Curing under nipa roof
Adcock	I–8	III–7	II–7	IV–8
Warne	I–1	III–3	IV–5	II–4
Big Warne	I–2	III–2	IV–4	II–3
Conqueror	III–3	II–1	I–1	IV–1
North Carolina Bright Yellow	I–6	III–4	II–2	IV–7
Gold leaf	I–5	III–5	II–6	IV–2
White Stem Orinoco	I–4	II–6	III–8	IV–6
Longleaf Gooch	I–7	IV–8	III–3	II–5

Roman number=Order of yellowness of each variety in the four methods of curing.
Arabic number=Order of yellowness of the varieties in each method of curing.

Yield.—The same figures for the check in the topping and irrigation experiments were used for yields. They are given in Table XI.

TABLE XI.—*Yields of cigarette tobacco varieties at the Alabang Rice Station, 1931–1932 season*

Variety name	Yield per hectare in kilos
Adcock	2,142.8
Conqueror	999.9
Big Warne	1,338.2
Warne	773 7
Goldleaf	1,160.7
White Stem Orinoco	857.1
North Carolina Bright Yellow	1,010.7
Longleaf Gooch	832.1

DISCUSSION OF RESULTS

It will be noted in the foregoing paragraphs that only two experiments were conducted at the Ilagan Tobacco Station. Namely, curing experiments and variety tests. On the other hand at the Alabang Rice Station, besides these two there were also topping experiments and irrigation experiments.

RELATION OF SOIL AND CLIMATE TO THE QUALITY OF LEAVES

Although no elaborate studies were made with regard to color and aroma of leaves for each of the varieties grown in the two stations it can be stated in a general way that as far as our observations are concerned, under the same treatment the leaves produced in Alabang were more aromatic and more yellow than those produced in Ilagan. If climate and soil have any influence

at all upon these two much coveted characters of cigarette tobacco leaf, by referring to Tables II, III, VI, and VII, it will be seen that the soil in Alabang is much heavier in texture and poorer in phosphoric acid than the soil at Ilagan. With regard to temperature and relative humidity they are generally higher in Ilagan. As to rainfall, beginning from the month of January to the month of April there was practically no more rain in Alabang, while in Ilagan there was still a moderate amount. In other words the dry season in Alabang is much longer and more distinct than in Ilagan.

Experiments on production.—Referring to Tables V and XI, it will be readily seen that those varieties grown at the Alabang Rice Station gave a much higher yield than those planted at the Ilagan Tobacco Station. Take the *Adcock* variety for example. This variety gave a total yield of 2,142.8 kilos of cured leaves per hectare in Alabang against 424.0 kilos in Ilagan or approximately five times as great. In the case of the *North Carolina Bright Yellow* variety the difference in yield was much greater. In Alabang the yield was 1,010 kilos per hectare while in Ilagan it was only 179.8 kilos or more than five times less. The same thing was true with the *Orinoco* variety, although to a lesser degree. In Alabang, the yield per hectare of this variety was 857.1 kilos against 466.5 kilos in Ilagan.

Generally speaking the low yield in Ilagan was not at all surprising as there were several factors that contributed to the failure of the crop. First of all, when the seedlings were ready for transplanting the land was prepared in spite of the torrential rain. The seedlings were planted under the same conditions. As a result when the sunny days came the soil baked and became very hard. Consequently the plants became stunted. In brief the low yield in Ilagan was due to the abnormal weather conditions which prevailed in that locality during the tobacco season. Taking everything into account, however, the yield in Alabang can be considered high enough even if compared with the normal crop in the Cagayan Valley.

The effect of the different methods of curing on the color of the leaves.—This particular phase of the work on cigarette tobacco may be considered as the most important, as the much desired yellowness of the leaves can only be produced through proper curing. Probably about 50 per cent of the market price of the leaves is based upon the degree of yellowness of the leaves. So far no other artificial process is known that is used commercially in the production of yellow leaves.

1. *Sun curing.*—The results obtained in the sun curing experiments conducted in Ilagan were a total failure. In general the check or the leaves cured under the shade produced better results than the sun-cured leaves as far as yellowness of the leaves was concerned. The color of the leaves cured in the sun was always dark brown. This statement is based upon a sufficient number of trials. In our opinion the dark curing quality of the leaves was caused by the high relative humidity which characterizes the condition in Ilagan. With this information on hand it is not advisable to cure cigarette leaf tobacco in the sun in places with conditions like those in Ilagan if the object is to produce yellow leaves.

A similar study was made at the Alabang Rice Station. The results may be seen in Table X. It is quite interesting to note that of all the methods tried there complete sun-drying gave the best results. It is followed by that method where the leaves were first placed in the camarin until they became yellow, then in the sun until they became thoroughly dry. Complete curing under a galvanized iron roof gave better results than that one where the leaves were completely cured inside the camarin. The eight varieties tested under complete sun-curing named in the order of yellowness, are as follows: *Warne, Big Warne, Conqueror, White Stem Orinoco, Goldleaf, North Carolina Bright Yellow, Longleaf Gooch*, and *Adcock*. It might be mentioned in this connection that although the *Adcock* variety grown in that station produced leaves which were not so yellow as the others, it gave the highest yield per hectare.

2. *Flue-curing.*—As far as the writers are aware this is the first time in the Philippines that cigarette tobacco leaves were cured properly in a regular flue-curing barn.

Because of the fact that many of the leaves were maturing in the field too fast to be accommodated in the flue-curing barn only five methods were tried. The information gathered from these trials however, is considered adequate to help those who want to venture on the commercial production of yellow cigarette tobacco in the Cagayan Valley and similar regions

In Table IV, the results and observations for each method are given in a general way. It will be noted in method No. 1 that the highest temperature reached was 51° C., and it took 34 hours to reach this temperature. The air was maintained at this temperature until the leaves became dry, it being believed that this temperature was sufficient to fix the color. But after a few days it was noticed that those leaves which were originally

yellow had turned dark brown. This trial led us to the conclusion and as previously reported that the color could not be fixed at that temperature. Another thing which we learned from this method was that rapid heating tended to make the color of the cured leaves greenish in color as attested by about 75 per cent of the leaves which were actually cured this way.

In method No. 2, in which the temperature was raised gradually to 66° C. much more satisfactory results were obtained. In this trial about 50 per cent of the entire leaves turned yellow. Also the color of the leaves remained unchanged showing that drying the leaves at 66° C. was sufficient to fix the color. In this trial it took 82 hours before the temperature reached 66° C. and it required another 12 hours to completely dry the leaves. In other words it took practically four days to complete the curing of the leaves.

In method No. 3, an outline similar to that one used in method No. 2 was followed, except that it took eight hours less before 66° C. was reached. In this method the leaves of three different degrees of ripeness were cured in order to find out the relation of color of the leaves in the field at the time of harvesting to the color of cured leaves. The different colors of the leaves when harvested were (1) dark green, (2) very light green with a light shade of yellowness, and (3) leaves with yellowish tips and margins. It was noted that the dark green leaves retained their original color after curing; very light green leaves with light shade of yellow turned yellow and leaves with yellowish tips and margins became dark brown.

It will be noted in method No. 4 that the temperature was raised very gradually. Because of the poor kind of fuel that was used it was not possible to raise the temperature beyond 61° C. although the original outline called for 66° C. About 50 per cent of the leaves in this method turned yellow but after some time the color faded. This shows that even at 61° C. the color could not be fixed.

Method No. 5 is identical with that found best by the senior author in his experimental curing box in 1929. The results obtained were not satisfactory because the rise in temperature for the beginning of the fixing of the yellow color, was allowed to take place before the leaves yellowed. Consequently, the leaves cured were all greenish. The difference in construction and flue arrangement of the box and barn may also account for the adverse result in the latter.

Our observations on the operation of the flue-curing barn may be briefly summarized as follows:

(1) Only leaves of the proper degree of ripeness will turn yellow in curing. Leaves which are either too green or overripe when harvested will become greenish and dark brown in color respectively after curing.

(2) Raising the temperature too fast tends to make the cured leaves greenish in color, as they dry before the yellow stage is reached. The temperature should be raised by not more than one degree centigrade for every three hours until the yellow stage is reached.

(3) As previously reported the minimum temperature that will fix the color is at least 66° C. A lower temperature than this is likely to fail to fix the color no matter how long the leaves are dried.

(4) The leaves should be thoroughly dried before the firing is stopped. If not sufficiently dried they are likely to develop dark brown spots, thus coloring with no uniformity. They are also subject to the attack of mold.

(5) The relative humidity inside the barn should be maintained at 80 per cent at least until the yellow stage is reached. This can be done by placing some wet rags inside the barn. It was observed however, that the leaves in the process of curing will give off sufficient moisture to make conditions inside the curing barn right. When the leaves are about to reach the yellow stage it is always advisable to open the door and windows of the barn in order to allow free circulation of air inside the barn but at the same time the leaves must not be allowed to dry too rapidly.

(6) Only hardwoods like guava or ipil-ipil should be used for fuel. It was found quite difficult to raise the temperature to as high as 66° C. with the use of softer wood.

(7) It is not advisable to cure leaves of different varieties together as no leaves of two different varieties are exactly alike in thickness, size of midribs and texture. In other words each variety will require a certain length of time to cure. Take the *Adcock* variety during the season, for example. This variety has very thick leaves with very prominent midribs and veins. They take a longer time to dry than the leaves of other varieties.

Effect of topping on the color and yield of cigarette tobacco.—It will be seen in Table XIII that with all the varieties tested

in this experiment at the Alabang Rice Station, the check or the untopped plants gave a bigger yield than the topped plants. In the case of the *Big Warne* for example the yield per hectare of the check was 1339.2 kilos against 595.17 kilos of the topped or a difference of 744.1 kilos. This was closely followed by the *Adcock* variety where the difference in favor of the check was 556.5 kilos. In our opinion the topped plants gave less yield than the check in all cases because these varieties in general are early maturing. By the time the plants produce flower heads they have a comparatively slow growth because the dry season is already far advanced and topping might have had a retarding effect under the circumstances.

As to the effect of topping on the color of the leaves it is hard to make any general statement. All that we can say at present in so far as our findings are concerned is that with some varieties topping induced the production of yellow leaves while with other varieties it was not so. The varieties which produced more yellow leaves when untopped were as follows: *Conqueror* 73 per cent, *Warne* 62 per cent, and *Big Warne* 50 per cent, while the varieties where topping was quite effective in the production of yellow leaves were the *White Stem Orinoco,* 55 per cent, *Goldleaf* 53 per cent, and *Adcock* 42 per cent.

Effect of irrigation on the color and yield of cigarette tobacco.—This experiment, which was also conducted at the Alabang Rice Station, showed that the check plants in all cases gave a higher yield per hectare than the irrigated for all the varieties tested except the *Warne* variety in which the irrigated plants gave a yield of 29.82 kilos more than the check. (See Table IX.) The five varieties in which the check gave a better yield than the irrigated may be enumerated in the order of their gain in yield per hectare as follows: *Adcock* 833.38 kilos, *Big Warne* 749.99 kilos, *Goldleaf* 537.14 kilos, *White Stem Orinoco* 148.74 kilos and *Conqueror* 107.14 kilos. In this connection it may be added that since the soil used in this experiment was clay, it retained too much of the irrigation water and the excess of moisture in the soil may have had a detrimental effect upon the growth of the plant. This condition may account for the low yield from the irrigated plants.

As to the effect of irrigation on the color of the leaves, as was the case in the topping experiments, it has a beneficial effect on some varieties only. The following varieties gave a higher

per cent of yellow leaves when irrigated: *White Stem Orinoco* 54 per cent, *Goldleaf* 54 per cent, and *Adcock* 48 per cent. The varieties in which the check gave a higher per cent of yellow leaves were the *Conqueror*, and the *Warne* with 73 per cent and 63 per cent of yellow leaves respectively. In the case of the *Big Warne* variety both the irrigated and the check gave 50 per cent of yellow leaves each.

Estimate of the quality of the leaves produced in general.— The leaf samples of the different varieties of cigarette tobacco produced from the Ilagan Tobacco Station and Alabang Rice Station which were exhibited June 15, 1932, at a demonstration in modern methods of cigarette manufacture at La Insular Cigarette Factory received high praise from those who saw them. They were put side by side with the imported leaves and many people were not able to distinguish one from the other without being told. In fact our samples were as good as, if not better than, some of the imported leaves, as far as yellowness and aroma are concerned. The final test of our samples with regard to smoking qualities must wait for a year as they must be aged this long at least.

CONCLUSIONS AND RECOMMENDATIONS

(1) Yellow cigarette tobacco can be grown successfully under a wide range of soil conditions as long as the land is well drained.

(2) For maximum production the *Adcock* variety is highly recommended in places with conditions similar to those at Alabang.

(3) If sun curing is practised at all, in order to obtain yellow leaves it should be in regions where there is a distinct wet and dry season. The planting should be planned in such a way that the harvesting of leaves coincides with the driest part of the year.

(4) The leaves should be thoroughly dried in curing as any excess moisture in the leaves will tend to produce brown spots and will encourage the growth of molds. The leaves must be put in close wooden containers like barrels and boxes after curing in order to conserve the aroma and flavor of the leaves.

(5) Growers who insist on raising cigarette tobacco in regions like the Cagayan Valley, where sun curing was found not practicable, must use flue-curing barns. And they have to do so at the risk of considerable expense.

BIBLIOGRAPHY

1. ALDANESE, VICENTE. Annual Reports of the Insular Collector of Customs, 1918–1931. Manila.
2. GARNER, W. W., MOSS, E. G., YOHE, H. S., WILKINSON, F. B., and STINE, O. C. History and Status of Tobacco Culture. United States Department of Agriculture Yearbook for 1922, pp. 395–468. Washington, 1932.
3. PAGUIRIGAN, DOMINGO B. Experiments on Cigarette Tobacco Production in the Cagayan Valley, 1925–1929. Philippine Journal of Agriculture, I: 1–36. Manila, 1930.

THE PROXIMATE CHEMICAL COMPOSITION OF PHILIPPINE FEEDS

By F. T. Adriano

Acting Chief, Agricultural Chemistry and Soil Technology Section
Bureau of Plant Industry

The author has been requested from time to time to furnish data on the chemical composition of various kinds of feeds. In going over his records and published work on the result of analysis of different plant materials, he finds that he can compile a table of chemical composition of various kinds of roots and tubers, cereals, leaves, hays, grasses, oil meals, and other feeding materials which should prove useful to an animal husbandman.

With the help of chemical analysis one is able to use his feeds more economically, purchase them more cheaply and prepare any mixed feed of the desired composition.

While most feeding standards have been based on the chemical composition, that is, on the basis of their fat, protein and carbohydrate contents, the discoveries of recent years have shown that the quantity and quality of mineral matter and the compounds of unknown chemical composition commonly known as "vitamins" are equally important in animal nutrition. With respect to the mineral matter, it has been found for example, that in the case of growing pigs, quite frequently it is necessary to add calcium to their rations in order to furnish this essential element for their proper growth and development. The injurious effects of a lack of mineral matter have been repeatedly demonstrated and now proper attention is focused on the compounding of feeding mixtures which adequately supply these essential mineral elements. Besides calcium and phosphorus, the absence of small amounts of elements such as iodine are known to be the cause of certain abnormalities—goitre, for one. It is apparent, therefore, that the determination of the essential inorganic constituents of feeds is also very important. Besides the proximate chemical composition and the quantity and quality of mineral constituents, recent researches have also shown that the absence of certain substances of unknown chemical composition called

"vitamins" is responsible for deficiency diseases which have been frequently observed both in humans and animals. These are Vitamin A, fat soluble; Vitamin B, water soluble; Vitamin C, antiscorbutic; Vitamin D, antirachitic; and Vitamin E, a vitamin necessary for reproduction. The absence of Vitamin A, as shown by experiments in feeding animals with substances which have been freed from fatty substances, caused them to fail to grow and eventually die, but the addition of butter fat or milk substances, which are equally rich in this kind of vitamin, to their vitamin-deficient diets restored normal growth.

The cereals are especially lacking in fat soluble vitamin, but it has been found that the leafy parts of the green plants are rich in this substance. The *pasturing of animals in the open where they can secure greens of various kinds is therefore important.* The absence of water soluble Vitamin B produces a disease which is commonly called "beri-beri." This vitamin has been found abundant in foods such as cereals and other feeds, milk, for example. Most ordinary rations for livestock, therefore, contain an ample supply of this vitamin. Vitamin C or the antiscorbutic vitamin which produces the disease known as "scurvy" of humans, monkeys and guinea pigs, is found not especially important to farm animals. It is present in fresh milk, fresh vegetables and meat but in very small amounts in cereals. Vitamin D or the antirachitic vitamin, the absence of which is the cause of rickets and the poor accumulation of calcium and phosphorus in the body is found important in the ration of dairy cows, young pigs and chickens. Vitamin E, or the reproduction vitamin is necessary in the successful reproduction of certain kinds of animals.

It is apparent, therefore, that a feed should be compounded not only on the basis of its proximate chemical composition but also with respect to the quantity and quality of its mineral constituents and its essential vitamins. As most of the essential vitamins are found in fresh and leafy parts of plants, *green pasturing is therefore essential in any livestock farming,* I repeat.

A brief explanation of some of the important terms used are given below:

Moisture.—In any kind of analysis, it is desirable to determine the percentage of volatile substances present in a given material which are given off when it is heated, at ordinary

pressure, to the temperature of boiling water (100° C.). This is done by using a Freas electric oven kept at 100° C ± 0.1° C. The loss obtained by this treatment is reported as moisture. Even the apparently dry materials lose some weight when kept under this temperature for several hours. A large amount of moisture is objectionable, especially if the materials are not fresh. When the moisture is not more than about 12 per cent the material is said to be air dry.

Fats or ether extract.—Crude fats or ether extract, is a term which includes all substances soluble in ethyl ether. They are composed mainly of the oil and fat contents of the material. Fat is used in the animal body as a source of fat and to furnish heat and energy. One gram of fat is 2.25 times as efficient as the same amount of carbohydrates in supplying body heat and for storing up fat in the body, though both are used for practically the same purpose in the body processes of the animals.

Protein is the constituent of the feed which forms flesh, muscle, hair, ligaments and other portions of the body. It replaces the wear and tear of the animal tissue and furnishes when burned some body heat. It is the most expensive portion of the feed.

Crude fiber is the residue obtained by treating a sample alternately in boiling dilute acid and alkali. The complex bodies which are obtained by this treatment are evidently not definite chemical compounds but are composed of mixtures of compounds generally known as "celluloses." They have comparatively little food value. Materials of high crude fiber content are usually of low digestibility.

Ash is the residue which remains after a sample is completely burned up. It includes all the mineral constituents that may be found in the material, usually in the form of oxides.

Nitrogen free extract is composed of starches, sugars, dextrins and other substances of similar nature. This is usually obtained by adding the percentages of moisture, ash, fats, protein and crude fiber and subtracting the total from 100.

Carbohydrates are the sum of the crude fiber and the nitrogen free extract.

Nutritive ratio is the proportion of the protein to the non-protein content of the feed. In calculating the nutritive ratio of a feed, the amount of fats, expressed in per cent, is multiplied by 2.25 and the product is added to the amount of carbohydrates

and the total is divided by the amount (percentage) of protein in the feed. The amount of fat is multiplied by 2.25 because it was found that the fat is 2.25 times as efficient as carbohydrates in producing energy.

Example.—Suppose a feed has the following composition: Fats 4.46 per cent, carbohydrates 46.43 per cent and protein 34.82 per cent. By applying the formula, the nutritive ratio will be found to be 1 to 1.62.

Whenever the nutritive ratio of any feed is desired, it is obtained by following the foregoing calculations.

REFERENCES

1. ADRIANO, F. T. 1925. The proximate chemical analyses of Philippine foods and feeding stuffs. The Philippine Agriculturist, 14: 57–91.
2. ADRIANO, F. T. and F. O. SANTOS. 1928. The chemical composition of Philippine food materials. Public Welfare Commission Circular, Bureau of Printing, Manila.
3. ADRIANO, F. T. 1929. The proximate chemical analyses of Philippine foods and feeding stuffs. II. The Philippine Agriculturist, 18: 119–125.
4. ADRIANO, F. T., ET AL. 1932. The proximate chemical composition of Philippine foods and feeding stuffs. III. Philippine Agriculturist, 20: 530–534.
5. ADRIANO, F. T. 1932. The chemical composition of some Philippine poultry feeds. Philippine Poultry Journal, 1: 6–7.
6. HENRY, W. A. and MORRISON, F. B. 1929. Feeds and feeding, Abridged. 18th ed. 440 pp. 114 figs. The Henry Morrison Co., Ithaca, N. Y., U. S. A.
7. SHERMAN, H. C. and SMITH, S. L. 1922. The vitamins. 273 pp. 20 figs. The Chemical Catalog. Co., New York, U S. A.

TABLE I.—*The chemical composition of some Philippine feeds*

Materials	Number of analyses	Moisture	Ash	Proteins	Fats	Carbohydrates		Nutritive ratio
						Crude fiber	Nitrogen free extract	
CEREALS								
1. Adlay–Coix lachryman-jobi Linn.	3	12.90	0.42	9.23	0.31	0.21	76.93	8.41
2. Corn–Zea mays Linn.	4	13.86	1.87	8.80	3.10	2.97	69.40	8.68
3. Cowpea Vigna sinensis (Linn.) Savi en Hassk.	1	12.73	4.31	19.61	2.39	4 68	66.28	3 65
4. Habichuelas–Phaseolus vulgaris Linn.	1	12.82	3.51	21.06	0.55	2.92	59 14	2.87
5. Mungo Phaseolus aureus Roxb.	1	13.53	3.60	17.85	1.20	1.52	62.30	3.64
6. Palay–Oryza sative Linn.	3	.36	5.85	5.64	1.63	9.62	63.90	11.98
7. Rice–Binlid.	3	.47	5.19	6.42	1.26	5.83	67.83	11.01
8. Rice–bran.	13	.17	13.67	10.44	7.71	13.37	42.64	5.74
9. Soy bean–Glycine max (Linn) Merr.	3	12.72	4.04	21.42	8.78	7.98	45.06	3.02

TABLE I.—*The chemical composition of some Philippine feeds*—Continued

Materials	Number of analyses	Moisture	Ash	Proteins	Fats	Carbohydrates		Nutritive ratio
						Crude fiber	Nitrogen free extract	
LEAVES								
1. Olasiman—Portulaca oleracea Linn.	1	90.06	2.14	1.69	0.15	0.64	0.34	.40
2. Australian fodder	1	.74	7.02	5.28	2.39	30.59	41.98	9.03
3. Camote leaves—Ipomea batatas (Linn.) Poir.	1	89.56	1.57	1.41	2.61	1.86	2.89	6.37
4. Corn leaves (air dry)—Zea mays Linn	1	12.61	9.03	9.29	1.43	24.53	43.11	4.99
5. Ipil-ipil (air dry)—Leucaena glauca (Linn.) Gaertn.	1	10.18	8.17	23.88	2.31	28.35	27.11	1.35
6. Oats hay U. S. Army (air dry)	1	11.53	3.43	9.16	1.44	12.45	61.99	7.12
7. Peanut leaves—Arachis hypogaea Linn.	1	11.04	8.57	11.38	2.56	32.61	33.84	3.48
8. Soy bean (air dry)—Glycine max (Linn.) Merr.	1	13.42	7.50	12.70	3.16	30.69	32.53	3.12
9. Sugar cane tops—Saccharum officinarum Linn.	1	.76	2.45	2.06	0.81	12.01	8.91	5.21
MEALS								
1. Copra meal (air dry)	18	.08	6.61	18.06	10.28	13.62	40.35	3.61
2. Fish meal	2	.33	14.59	58.94	3.15	0.33	9.66	.28
3. Kapok seed meal—Ceiba pentandra (Linn.) Gaertn.	1	.87	7.96	22.88	4.48	14.53	36.28	2.03
MISCELLANEOUS								
1. Molasses	1	55.10	3.47	0.78	0.15	40.50	.....	52.36
2. Shrimps dried (small)	1	14.55	19.73	55.61	2.61	4.42	3.26	0.34
3. Snails	1	.22	6.06	7.62	0.75	7.35	.....	1.18
ROOTS OR TUBERS								
1. Arrowroot (air dry) Maranta arundinacea Linn.	1	.62	5.58	4.79	0.68	1.77	78.66	16.74
2. Cassava—Manihot utilissima Pohl	2	.36	1.17	0.71	0.17	1.32	28.87	41.20
3. Gabi (air dry) Colocasia es- (Linn.) schott	.....	.....	4.81	7.57	0.74	1.71	79.48	40.72
4. Palawan—Cyrtosperma merkusi (Hassk.) shott.	3	.09	1.37	1.00	.....	1.35	32.50	33.40
5. Pongapong (fresh)	3	.....	0.72	0.31	0.23	1.05	3.07	11.57
6. Camote (air dry)—Ipomoea batatas (Linn.) Poir.	5	9.58	2.35	10.00	15.88	19.51	42.68	7.84
GRASSES								
1. Ambabanguet	1	79.74	8.33	1.97	1.14	3.50	5.32	4.00
2. Aguingay (fresh)—Rottboellia exaltata Linn. f.	5	71.34	3.90	2.25	1.35	9.42	11.74	6.55
3. Barit fresh—Leersia hexandra Sw.	1	70.91	4.63	1.81	1.55	8.70	12.40	8.78
4. Barit dry—Leersia hexandra Sw.	.....	24.10	14.04	7.04	1.76	23.12	29.9	4.81
5. Batad-batadan (air dry) Andropogon halepensis var. propinquus (Kunth) Merr.	1	12.43	9.23	4.63	0.40	29.70	43.61	9.61
6. Bayakibok—Panicum crusgalli	1	82.59	2.09	2.74	0.25	5.11	7.22	2.84
7. Bermuda fresh—Cynodon dactylon (Linn.) Pers.	1	42.73	6.14	8.10	0.79	15.29	26.95	3.55
8. Bermuday dry—Cynodon dactylon (Linn.) Pers.	1	10.08	7.53	6.41	2.20	22.28	51.50	8.81
9. Carirawraw fresh—Digitaria corymbosa.	1	71.57	4.42	2.01	0.76	8.38	12.86	7.25
10. Carirawraw dry—Diggitaria corymbosa.	1	.87	11.66	5.78	1.83	24.45	45.41	8.57
11. Cogon fresh—Imperata cylindrica var. koenigili (Retz.) Benth. ex. Pilger	9	00.00	3.68	2.47	0.85	11.62	14.38	6.60

TABLE I.—*The chemical composition of some Philippine feeds*—Continued

Materials	Number of analyses	Moisture	Ash	Proteins	Fass	Carbohydrates		Nutritive ratio
						Crude fiber	Nitrogen free extract	
GRASSES—Continued								
12. Cogon dry—Imperata cylindrica var. koenigili (Retz.) Benth. ex. Pilger	1	.87	9.30	5.19	1.51	37.99	38.14	8.00
13. Cogon roots—Imperata cylindrica var. koenigili	1	68.53	1.87	0.41	0.86	10.53	17.80	48.13
14. Culape fresh—Pasupalum conjugatum Beng.	4	.62	2.77	2.15	0.89	6.84	11.73	6.39
15. Culape dry—Pasupalum conjugatum Berg.	1	10.89	9.97	4.88	0.61	22.88	50.77	10.68
16. Dawa-dawa—Panicum crus-galli Linn	1	.31	9.68	3.66	0.42	26.88	44.05	12.29
17. Guatemala—Tripsacum laxum	1	85.15	3.18	2.13	1.98	6.04	1.52	2.80
18. Guinea—Panicum maximum Jaco.	16	73.01	4.00	2.06	0.82	8.86	10.75	6.11
19. Machia fresh—Mimosa pudica Linn.	1	.79	1.02	4.63	2.28	6.63	11.65	3.62
20. Macahia dry—Mimosa pudica Linn.	2	.16	4.25	14.52	2.62	18.45	49.30	3.80
21. Marker Fresh—Pennisetum markarii	4	83.04	3.36	1.71	0.59	4.88	6.42	4.53
22. Napier fresh—Panicum barbinode	19	.28	2.82	1.34	0.44	5.71	7.41	6.27
23. Napier dry—Panicum barbinode	1	.15	13.18	7.28	0.85	25.78	41.76	6.00
24. Paraguis (fresh) Eleusine indica (Linn.) Gaertn.	3	.35	2.27	1.39	2.04	5.46	14.49	13.73
25. Paraguis (air dry) Eleusine indica (Linn.) Gaertn.	1	11.09	12.75	6.88	1.97	22.21	45.10	7.20
26. Panisetum sotesum (fresh)	2	91.20	2.36	1.36	0.42	3.45	1.21	1.58
27. Sabungsabungan (air dry)—Panicumflavidum	1	14.01	12.49	8.36	0.26	24.54	40.35	3.90
28. Sectaria palmifolia (air dry)	1	8.90	12.28	7.88	0.23	29.39	41.32	5.31
29. Talahib (dry)—Saccharum spontaneum Linn.	2	.30	11.13	6.38	1.05	33.11	35.03	3.32
30. Talahib (fresh)—Saccharum spontaneum Linn.	1	.09	2.36	1.51	0.52	8.26	8.06	6.11
31. Tiribuhan (air dry)	1	.40	18.27	6.72	1.65	24.03	38.93	6.34
32. Tritiguhan (fresh)	1	.88	4.57	2.28	1.17	10.81	17.29	8.74

PROGRESS REPORT ON CITRUS HYBRIDIZATION

By Juan P. Torres

Plant Breeder, Bureau of Plant Industry

The hybridization work on citrus was started four years ago in Tanauan Citrus Station, Tanauan, Batangas. So far as the author could find from available references on citrus, no hybridization work with this plant was ever done in the Philippines prior to 1928, although as early as 1911 the Bureau and College of Agriculture had introduced into the Islands many varieties and species and hybrid forms of citrus. Citrus hybridization was initiated by the writer in March, 1928, during his official visit to Tanauan. From then until the 1930 flowering season this work was carried on as a project of minor importance and was mainly handled by Junior Agronomist Faustino Marajas of the station. In the 1931 flowering season, however, the writer assumed full charge of the work as he was then assigned to citrus selection and hybridization work.

This paper presents the progress of citrus hybridization work, including some notes on citrus pollination, technique and the results of crossing thus far obtained.

NOTES ON CITRUS POLLINATION

The following notes on pollination in citrus were made by the writer in Tanauan Citrus Station and in Lamao Experiment Station, Limay, Bataan, during the last three flowering seasons.

It was found that unlike many other plants such as avocados, mangoes and some others, citrus has no specific time for the general opening of the flowers of individual varieties. The floral opening takes place any time of the day or night, depending upon the internal conditions favorable for the flower's behavior. As soon as the flower opens the stigma usually is in the receptive stage except in the variety Kishiu in which, during the regular season, the pollen habitually matures a day earlier than the stigma.

The time of dehiscence seems to vary in different species. In common sweet oranges, *C. sinensis*, dehiscence starts shortly after 7 o'clock in the morning or a few minutes earlier during bright

sunny days, whereas, in mandarins, *C. nobilis,* the anthers usually start discharging pollen shortly after 10 a. m., while most of the pummelo flowers discharge pollen in the afternoon and some may burst in the morning, especially an hour or so after a morning rain. In lemons, *C. limonia,* pollen may be discharged any time during the day.

As a rule, in citrus the stigma remains receptive for a long while after the flower has opened. This condition together with insect activities in pollination, accounts for the great possibility of natural crossing between species and varieties of citrus. In fact, great affinity in cross-fertilization obviously exists between varieties and between so-called species as proved by the results of Swingle's interspecific hybridization and those of some recent work of the writer's. Mendiola (1926) mentioned the report of Barrett in Sicily that most of the 30 true hybrids out of 200 varieties are natural crosses. In the Philippines, it is not improbable that some of the so-called new species of citrus may later be found out to be natural hybrids.

Some varieties of citrus are pollenless, notably, the Washington Navel orange, *C. sinensis,* and Tahiti lime, *C. limonia.* The fruits usually develop parthenocarpically, i. e., without the aid of pollination and fertilization. In the Tahiti lime not a single seed has yet been found. The Washington Navel, although destitute of pollen, frequently produces few seeds that are attributed to chance cross-pollination.

The Washington Navel usually produces abundant flowers during regular seasons both in Lamao and the Tanauan Citrus Station, more frequently in the latter place; but it has always proved to be a shy bearer. Repeated observations have shown that few or no fruits remain to mature whenever frequent rains coincide with the flower opening period. However, a greater percentage of setting comes from flowers borne in the dry months of February and March. It seems as if rain is inimical to the good setting of the Washington Navel. Nevertheless, it is not definitely known whether the poor setting on rainy days is due to the effect of rain or to the periodical abundance of rindborer insects to which the flowers and young fruits are extremely susceptible. Observations have shown that both the early flush of flowers and young fruits and those of the season suffer considerably from the attack of the rindborers.

The varieties of sweet oranges Valencia, Excelsior, Enterprise, Carleton, and an unidentified variety which, for convenience, was named Tanauan Seedless orange, and the Tizon mandarin produce

abundant pollen yet their fruits contain less seeds than most other varieties. Partial sterility seems to exist in these varieties of citrus.

As before stated, in the variety Kishiu the pollen, in the regular season, matures a day earlier than its own stigma. The stigma becomes receptive the following morning after the flower has lost its means of attraction to insects, as then all the petals have fallen. The indications are that this unequal ripening of the flower organs accounts for the shy bearing habit of this particular variety. Resulting from some pollination not directly by insect agents but with stray pollen grains, some fruits develop on the inner twigs. The absence of fruits on the terminal twigs further shows the effect of poor pollination upon the productivity of the Kishiu variety.

Notwithstanding this it has been noted that there is a greater setting of fruits from the off season flush of flowers, in February and March. The ripening of pollen and stigma synchronizes at that time of the year; consequently, some fruits develop even on the terminal twigs. It may be conceded, therefore, that with Kishiu as well as with Washington Navel, fruit production might be increased by means of forced blooming during the dry months of February and March.

The Siamese pummelos from Siam, with a reputation of being seedless in their country of origin, contain an incredibly large number of seeds in the normal sized fruits raised in the Tanauan and in Lamao Experiment Stations. The small or undersized fruits are more or less seedless. In these varieties there is abundant pollen which matures at the same time with normal stigma so that fertilization with its own pollen seems very probable. Nevertheless, about a hundred artificially self-pollinated flowers of the Siamese variety P. I. 3673 failed to produce a single fruit, thus suggesting self-incompatibility. However, the test is to be repeated for verification. There are good indications that the production of seeds in Siamese pomelos is due to the presence of other citrus varieties which greatly influence cross-fertilization.

OBJECT OF HYBRIDIZATION

The main object in citrus hybridization is the production of hybrids that are superior to either parents. With mandarins it is important to consider in hybridization such good characteristics, as the low habit of growth and spreading branches of the Kishiu variety, the good eating quality of Batangas man-

darins, the good flavor and excellent keeping quality and late maturity of the King variety, the low habit of growth, regular bearing habit and heavy yielding capacity of the Szinkom mandarin and the attractive reddish tinge of the Ladu and Dancy varieties.

The production of hybrid strains of oranges that are resistant to the attack of the rindborer is of paramount importance. Inasmuch as all existing varieties of oranges are more or less susceptible to this pest, the problem may involve crossing oranges with other species that are highly resistant to the rindborer. Many varieties of mandarin and some pummelos are quite resistant to the attack of this pest. The excellent eating quality and seedlessness of some Washington Navel strains, the good flavor of the Du Roi, Magnum Bonum, and Valencia varieties and the seedlessness of the Carleton and Tanauan Seedless oranges varieties are also important characteristics from the breeding standpoint.

The production of superior hybrids resistant not only to the rindborer but also to canker disease, is very important in connection with hybridization work with pummelos and grapefruits. The varieties of pummelos that are resistant to the rindborer are the Pink, La Union and Saigon, but each of these varieties has its own defects which may be lessened or eliminated through hybridization. The Saigon and La Union varieties are both juicy but the ripe fruits are tart, with a large proportion of acid to sucrose. The Pink pummelo is ever-bearing and ripens sweet but has rather little juice. The Nueva Ecija P. I. 7410–B, like the Saigon variety, is a regular bearer, productive and early, but the eating quality is poor. The Siamese pummelos are of good flavor but the flowers and young fruits are heavily attacked by the rindborers and the canker disease. The Vermilion variety, with large sized and attractive vermilion colored fruits, but of poor eating quality, has a low habit of growth and spreading branches. The production of seedless strains of pummelos and grapefruits is also a great commercial possibility.

The Panuban, a native grapefruit which is highly resistant to the rindborer and to citrus canker, is a promising variety for the production of superior hybrids if crossed with the more susceptible Marsh Seedless and McCarthy grapefruits, which are of better quality than the native sort.

With lemons and limes the problem consists in the production of hybrid strains resistant to canker and gumming disease. Lemons, with the exception of the Rough Lemon, are badly attacked

by gummosis irrespective of the kind of stocks they are budded on. The Rough Lemon variety, although much less productive than many other varieties, stands high as to resistance against gummosis and canker. Crossing it with less resistant but more productive types may be expected to produce superior hybrids. Lemons are less troubled by the rindborer than are limes. All limes except the seedless Tahiti lime are badly attacked by that pest. The larvæ of the rindborer insect are imprisoned and die in the rind of Tahiti lime in the same manner as in lemons. The type and size of fruit intermediate between the lime and lemon, the thickness of the rind and its reaction to rindborer attack and the decided sterility are good indications that the Tahiti lime is a hybrid between a lime and a lemon.

Considering the important characteristics of the different varieties of citrus the present breeding work has been instituted to produce superior hybrids from different crosses. Some of the most important ones are given in Appendix I.

TECNIQUE OF HYBRIDIZATION

Flowers that are about to open are emasculated. Open flowers may be treated likewise if they are kept previously in a bag and provided that the anthers are still closed. All unnecessary or surplus flowers and flower-buds are removed. The whole twig or small branch with a number of emasculated flowers may be inclosed in the bag. For bagging, cheesecloth or paper sufficiently strong to resist the effect of rain for several days may be used. Needless to say emasculation is unnecessary with pollenless and self-incompatible varieties. As soon as the stigma are found to be receptive, as indicated by the presence of a sticky fluid thereon, the emasculated flowers are to be cross-pollinated with pollen from the selected male parent.

The pollen is obtained from flowers picked just before opening or before it is discharged by the anthers. Then, these flowers are wrapped loosely in clean paper until the anthers commence to discharge pollen. The cross-pollinated flowers may be allowed to remain covered for two days or more until the stigma loses its receptiveness.

It is important to mention that the condition of the seed-parent tree, branch or twig from which to select flowers to be crossed, should be healthy in order to insure normal development of the fertilized fruits.

Care of hybrid fruits.—After the cross-polination, a label is attached to the twig. Either paraffinized cardboard or a thin

bamboo split is used. On the label are shown the date of pollination and the parent varieties; the seed-parent written first as in Szinkom X Batangas mandarin. Inspection is then made at frequent intervals so as to guard the hybrid fruits against any disorder until they mature.

The fruits of seed parent varieties that are highly susceptible to the attack of the rindborer are inclosed in cheesecloth bags in order to prevent damage, and lest the hybrid fruits fall before reaching maturity. Having grown to full size, the individual hybrid fruits, if not kept in bags, are marked on the rind, preferably with india ink or any pain harmless to the fruits but rainprof. This marking is essential as it distinguishes the hybrids from the non-hybrids fruits in case they drop to the ground before they are picked from the tree. In this connection, it is important to note that some of the seeds from full-sized but rather immature fruits are already germinable.

Germination and care of hybrid seedlings.—The seeds having been extracted from the fruits, are subsequently air-dried for an hour or two and then sown in seed flats with clean, rich garden soils, to germinate. As a precautionary measure against damping off, the soil is better sterilized before the seeds are sown. In sterilization hot boiling water may be applied at the rate of about a petroleum canful for every two or three seed flats made of halves petroleum boxes. Sterilization is done twice. Citrus seeds should not be dried hard in the sunshine as they soon lose their vitality if so treated.

After four or five months in the seed flat with constant good care as to watering and light cultivation, the seedlings are ready for pricking. At this stage or even earlier, the hybrids in the progeny from some crosses may be easily recognized as they usually are of intermediate forms between the parent varieties. The two classes of seedlings may be differentiated in one or more characteristics such as size and shape of leaves, size and nature of apex, serration of leaf-edge, and in size and shape of winged petioles. In some crosses the hybrids are very difficult to distinguish from the non-hybrid seedlings of the seed parents, whereas in the reversed mating the F_1 hybrids are more easily recognizable. In cases where the hybrid seedlings appear very similar to the non-hybrids of the same progeny, the differentiation may be observed only after some years of waiting for the fruiting of the F_1 seedlings.

The hybrid seedlings that are easily identifiable from the non-hybrids, are separated and transferred individually to pricking

boxes purposely made large enough to provide for at least a year's growth of the seedlings. An empty petroleum can may serve for planting a seedling. Seedlings that are planted in nursery beds are set at 40 to 50 centimeters each way in double rows, thus providing sufficient space for easy balling later on. The beds are heavily mulched with dried grasses or straw in order to economize labor and expense for cultivation, weeding and watering, especially during sunny days.

RESULTS OF HYBRIDIZATION

From the 1928 to the 1930 flowering seasons no less than seventy different crosses, involving 500 cross-pollinated flowers, were attempted. Of this number, six crosses, Table I, have produced some seedlings.

The general failure of the first three years' hybridization work was attributed to the fact that few flowers were employed in most of the crosses. No allowance was made for the natural fruit-fall from physiological, pathological and other causes. On this account the unsuccessful matings have been omitted from this report.

In the flowering season of 1931, twenty-seven crosses with a total of 1,034 cross-pollinated flowers, were made by the writer. The results are presented in Tables II and III. In Table III is given the list of 1931 successful crosses.

Discussion of results.—A glance over Table II will show that 6 out of 11 intraspecific crosses and in 3 out of 16 interspecific crosses were successful. Many crossess failed on account of the attack by rindborer. The damage was most severe in crosses with sweet orange seed parents. Here the importance of covering the young crossed fruits with cheesecloth, in order to prevent rindborer attack, is to be emphasized. With the Washington Navel orange used as seed parent the greatest loss occurred during the first 10 to 15 days after cross-pollination. This considerable loss of young fruits is attributed to the shy bearing habit of this particular variety, although the effect of rindborer attack on flowers and young fruits is no less important in this connection.

With the Villafranca lemon as seed parent, all crosses would have been successful had it not happened that the branches to which most of the crossed fruits were attached died of certain bark troubles. Evidently, the importance of selecting healthy branches or twigs on which cross-pollination is to be done should always be considered.

The mandarins, King and Szinkom, seed parent varieties gave 15 to 30 per cent setting from cross-pollinated flowers. These data disclosed the fact that, as a class of citrus, the mandarins are the least susceptible to the attack by the rindborer.

The data on hand for the last three years indicate that the Siamese varieties P. I. Nos. 3442 and 3673, are impregnable by pollen of mandarins, oranges, pummelos and lemons. This accounts for the fact that the so-called Siamese Seedless pummelos contain large number of seeds in the normal sized fruits. It was also observed that a heavy percentage of the young fruits and flowers are destroyed by the rindborer. Hence when this is used as a seed parent, the young fruits need protective covering to increase success in hybridization.

In the progeny of a single cross between citrus varieties and species with a polyembryonic seed parent, there are two classes of seedlings, the hybrids and nonhybrid seedlings. Means by which hybrid seedlings may be identified from the non-hybrid forms have been described elsewhere in this report. The hybrid seedlings originate from fertilized egg cells; hence, they are called sexual seedlings. On the other hand the non-hybrids develop from cells other than gametic cells. Thus, they are named asexual or apogamic embryos and the seedlings that develop from them are called asexual or apogamic seedlings. The apogamic seedlings, being asexually produced, are expected to be replications of the seed parent genotype without any variation due to recombination or fertilization.

In Table III, column 3, it can be seen that all seed parents, with the exception of the pummelos, are polyembryonic. In accord with these data, it may be important to mention that in a recent study made by the writer with different varieties of citrus it was found that all pummelos—not grapefruits—are uniformly of the monoembryonic type. This differentiation may serve to identify a pummelo from the grapefruits. With polyembryonic seed parents the total hybrids, column 4, are less than the number of seeds giving seedlings. The production of hybrid seedlings varies from 28.4 to 82.9 per cent, indicating that in some of the seeds the sexual embryos have been eliminated. Thus, according to Frost (1926), it is natural that the sexual embryo should have to struggle for existence with vigorous apogamic embryos in the same seed. He further states that in varieties having very vigorous apogamic progeny the number of sexual seedlings in the progeny is relatively small. At the present writing the

seedlings from King-Batangas mandarin cross are yet too small to be classified into hybrids and nonhybrid seedlings.

Referring to Table I, the seedling from the cross of Batangas X Szinkom and those from Orange No. 10 X Kishiu are all nonhybrid or apogamic seedlings. Only 2 out of 12 seedlings from the cross of Szinkom X King and 2 out of 14 seedlings from Szinkom X Batangas mandarin are hybrids or sexual seedlings. Seedlings from the cross of the Siamese 3442 X Vermilion pummelo and those from the Siamese 3442 X Saigon are all hybrids, as may be expected from any monoembryonic seed parent variety.

SUMMARY AND RECOMMENDATIONS

This progress report, being the first one on the subject of citrus hybridization in this country, has given more emphasis to the study of pollination and the technique of hybridization. In the study of pollination the following has been observed.

1. There is no specific time for the opening of the flowers of different varieties and species of citrus but species seem to vary in their time of dehiscence. In sweet oranges, *C. sisnensis*, dehiscence of pollen starts shortly after 7 o'clock in the morning; in mandarins, *C. nobilis*, it commences after 10 a. m.; in pomeloes *C. maxima* (*C. grandis*), most flowers discharge pollen in the afternoon although it was observed that some flowers dehisced pollen shortly after a morning rain; whereas, in lemons, *C. limonia*, dehiscence may take place any time during the days. Needless to state a knowledge of this floral action is essential for pollen collection and crossing.

2. As a rule the stigma, except that of the Kishiu variety, becomes receptive as soon as, or little before, the flower opens, with a brief period before the pollen becomes available, giving a good chance for natural cross-pollination in many varieties of citrus.

3. The Tahiti lime and Washington Navel orange are pollenless varieties. The former never has been found with a single seed, but the latter contains a few viable seeds that are attributed to natural cross-pollination.

4. There is good evidence that the presence of other citrus varieties promotes cross-pollination, resulting in seed production in Siamese seedless pummelos. Experiments to determine the factors influencing seed production in these varieties should be carried on next flowering season.

5. In the regular season, the pollen of the Kishiu variety matures a day earlier than its own stigma, resulting in imperfect

pollination, which logically accounts for the shy bearing habit of this particular variety. However, in the off season flush of flowers, those borne in the dry months of February and March, the pollen and stigma mature at the same time, thus, giving a higher percentage of fruit setting. This seems to suggest the possibility of increasing fruit production by means of forced blooming in February and March.

In the improvement of citrus by hybridization the following characteristics are considered very desirable: for mandarins, yields of regular production, good eating and keeping quality, low habit of growth and spreading branches, late maturity, attractive reddish color and tight articulation of fruits against windfalls; for sweet oranges, resistance to the rindborer, sweetness or good eating quality and seddlessness of fruits; for pummelos and grapefruits, resistance to the rindborer and canker disease, low habit of growth and spreading branches and seedlessness; for lemons, resistance to canker and gummosis; for limes, resistance to rindborer, gummosis and canker disease.

This report prescribes the technique of hybridization including care of hybrid fruits before maturity and of the seedling progeny while in seed flats and in nursery beds. Bagging of young crossed fruits, especially those from seed parent varieties that are highly susceptible to rindborer attack, has been pointed out emphatically. In addition, the importance of selecting healthy branches or twigs where crossing is to be performed, has been mentioned.

It has been observed that the progeny from citrus crosses with polyembryonic seed parent varieties segregated into two classes, namely, the hybrids or sexual seedlings and the nonhybrids or apogamic seedlings. The production of hybrids varied from 28.4 to 82.9 per cent of seeds giving seedlings, indicating that in some seeds the sexual embryos have been eliminated or crowded out by the more vigorous apogamic embryos in the same seeds. Hybrid seedlings have been obtained from the following citrus crosses:

1. King mandarin x Batangas mandarin.
2. Szinkom mandarin x Batangas mandarin.
3. Szinkom mandarin x King mandarin.
4. Szinkom mandarin x Tizon mandarin.
5. Siamese 3442 pomelo x Vermilion pummelo.
6. Siamese 3442 pomelo x Saigon pummelo.
7. Nueva Ecija pomelo x Siamese 3442 pummelo.
8. Panuban grapefruit x McCarthy grapefruit.

9. Siamese 3673 pomelo x King mandarin.
10. Villafranca lemon x Bahia orange.
11. Villafranca lemon x Nueva Ecija pummelo.

As many crosses as possible of those shown in Appendix I should be made this coming season.

BIBLIOGRAPHY

1. FROST, HOWARD B. Polyembryony, Heterozygosis and chemeras in citrus. Hilgardia *1:* 365–402. 1926.
2. MENDIOLA, N. B. A Manual or Plant Breeding for the Tropics. Chp. 12: Citrus fruits. 283–294. Phil. Bureau of Printing. 1926.
3. BARRETT, O. W. Natural citrus hybrids. Phil. Agr. Rev., *5:* 334–335. 1912.

APPENDIX I.—*List of important citrus crosses*

No.	Kind of cross	Date started	Remarks
	A. INTRASPECIFIC CROSSES		
	(1) *Citrus nobilis crosses:*		
1	King X Batangas	5–23–31	F_1 seedlings.
2	Szinkom X Batangas	5–23–31	F_1 seedlings.
3	Szinkom X King	5–23–31	F_1 seedlings.
4	Szinkom X Tizon	5–25–31	F_1 seedlings.
5	Kishiu X Szinkom	3– 9–32	
6	King X China		
7	King X Dancy		
8	King X Kishiu		
9	King X Ladu		
10	King X Satsuma		
11	King X Tizon		
12	Kishiu X Batangas		
13	Kishiu X China		
14	Kishiu X Dancy		
15	Kishiu X Ladu		
16	Kishiu X Tizon		
	(2) *C. sinensis crosses:*		
17	Washington Navel X Du Roi	3–26–32	
18	Washington Navel X Carleton		
19	Washington Navel X Laurel		
	(3) *C. grandis crosses:*		
20	Siamese 3442 X Varmilion	5–14–30	F_1 seedlings.
21	Siamese 3442 X Saigon	5–19–30	F_1 seedlings.
22	Nueva Ecija X Siamese 3442	5–27–31	F_1 seedlings.
23	Siamese 3442 X Pink		
24	Siamese 3673 X La Union		
25	Panuban X McCarthy	5–30–31	F_1 seedlings.
26	Panuban X Marsh Seedless		
27	Marsh Seedless X Pink		
28	Marsh Seedless X La Union		
29	Pink X Panuban		
	(4) *C. Limonia crosses*		
30	Thornless X Rough Lemon	3–15–32	
31	Villafranca X Rough Lemon	3–15–32	
32	Ureka X Rough Lemon		
	B. INTERSPECIFIC CROSSES		
1	Villafranca X Orange (Bahia)	5–28–31	F_1 seedlings.
2	Villafranca X Pummelo (Nueva Ecija)	5–28–31	F_1 seedlings.
3	Siamese 3673 X King	5–25–32	F_1 seedlings.
4	Kishiu X Orange (Jaffa)	5–26–32	
5	Pink X Batangas		
6	Pink X Orange (Laurel)		

TABLE I.—*Some results of 1929 and 1930 citrus hybridization*

Crosses	Date poliinated	Number blossoms	Number fruits harvested	Number seedlings
Szinkom X Batangas	2–12–29	26	9	14
Batangas X Szinkom	2–12–29	11	2	1
Szinkom X King	5–13–30	3	1	12
Orange No. 10 X Kishiu	1–29–29	3	1	5
Siamese 3442 X Vermilion	5–14–30	8	3	74
Siamese 3442 X Saigon	5–19–30	11	10	62

TABLE II.—*Results of 1931 citrus hybridization*

Crosses	Date pollinated	Number blossoms	Number fruits observed		Number fruits harvested
			June 7	August 21	
Citrus nobilis X C. nobilis:					
King (m) X Batangas (m)	5–22–32	39	20	15	11
Szinkom (m) Batangas	5–23–31	91	44	19	12
Szinkom X King	5–23–31	25	13	5	5
Szinkom X Tizon	5–25–31	38	30	14	13
C. sinensis X C. nobilis:					
Bahia (o) X Batangas	5–26–31	76	28	1 dr.	Sept. 7.
Bahia X King	5–26–31	45	22	all dr.	
Bahia X Tizon	5–20–31	19	14	all dr.	
Washington Navel X Tizon	5–25–31	20	all dr.		
C. sinensis X C. sinensis:					
Washington Navel X Orange No. 5	5–22–31	146	5	2 dr.	Sept. 9.
Washington Navel X Orange No. 10	5–23–31	99	all dr.		
C. sinensis X C. maxima:					
Bahia X Siamese (p) 3442	5–26–31	81	39	all dr.	
C. sinensis X C. limonia:					
Bahia X Villafranca (1)	5–26–31	85	34	all dr.	
C. maxima X C. nobilis:					
Siamese 3673 X King	5–25–31	20	7	2	2
Siamese 3673 X Batangas	5–27–31	11	3	all dr.	
C. maxima X. sinensis:					
Nueva Ecija (p) X Bahia	5–27–31	12	all dr.		
Siamese 3673 X Bahia	5–27–31	37	4	all dr.	
Vermilion (p) X Bahia	5–28–31	12	all dr.		
C. maxima X C. maxima:					
Panuban (Grft) X McCarthy grapefruit	5–30–31	12	8	3	3
Nueva Ecija X Siamese 3442	5–27–31	50	28	6	6
Siamese 3442 X Nueva Ecija	5–29–31	33	3	all dr.	
Vermilion X Siamese 3442	5–29–31	8	5	all dr.	
C. maxima X C. limonia:					
Nueva Ecija X Thornless	5–29–31	14	1 dr.		
Siamese 3673 X Villafranca	5–27–31	12	6	all dr.	
C. limonia X C. sinensis:					
Villafranca X Bahia	5–28–31	2	2	1	1
C. limonia X C. maxima:					
Villafranca X Nueva Ecija	5–28–31	17	17	9	5
Villafranca X Siamese	5–28–31	13	11	1 br.	Dis.
C. limonia X C. limonia:					
Villafranca X Thornless	5–28–31	22	18	br.	Dis.

N. B.—br.—branch; dr.—dropped; Grft.—grapeful; l.—lemon; m.—mandarin; o.—orange p.—pummelo; Dis.—diseased.

TABLE III.—*Successful citrus crosses in 1931*

Crosses	Number seeds giving seedlings	Total seedlings	Seedlings per cent seeds	Number hybrid seedlings	Hybrid seedlings per cent seeds
Nueva Ecija X Siamese 3442	416	416	100	416	100
Siamese 3673 X King	108	108	100	108	100
Panuban X McCarthy	70	78	111.4	58	82.9+3.0
Villafranca X Orange (Bahia)	21	22	104.8	15	71.4+6.4
Villafranca X Nueva Ecija	72	82	113.7	38	52.8+4.0
Szinkom X King	50	68	126.0	26	52.0+4.9
Szinkom X Tizon	130	167	128.5	48	36.9+2.9
Szinkom X Batangas	319	499	154.2	91	28.5+1.7
King X Batangas	179	194	108.3	.....	.....